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FOURTH REPORT

OF THE

GEOLOGICAL SURVEY

IN

KENTUCKY,

MADE DURING THE YEARS 1858 AND 1859,

BY

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ASSISTED BY

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FRANKFORT, KY.:
PRINTED AT THE YEOMAN OFFICE.
J. B. MAJOR, STATE PRINTER.
1861.

INTRODUCTORY LETTER.

His Excellency, BERIAH MAGOFFIN,

Governor of Kentucky:

SIR: Last October I forwarded a synoptical report of the results of the Geological Survey of Kentucky, from the conclusion of my previous report up to that time.

I now submit a full report of the geological surveys made, under my direction, in Kentucky, during the years 1858 and 1859.

Very respectfully, your obedient servant,

D. D. OWEN, *State Geologist.*

GEOLOGICAL REPORT.

CHAPTER I.

GENERAL GEOLOGY.

During the two past seasons, three very important works have been completed in the prosecution of the topographical, geographical, and geological surveys of the State of Kentucky.

The east and west base line, which is to serve as the basis for all the geographical and topographical surveys, by which the geological observations are to be finally located, has been completed. This line commences on the Ohio river, at the mouth of Highland creek, and runs due east until it intersects the boundary line between the States of Kentucky and Virginia. The principal points through which, or near which, this line passes, are: Commencing at the Monument Stone, in Dr. John T. Berry's inclosure, near Uniontown, approximate latitude 37° 46′ 4″. At 187,-369 feet it crosses Green river; at 233,300 feet it runs through the centre of Third street, in Owensboro; at 269,280 feet it crosses Panther creek; at 296,318 feet passes through Knottsville, in Hancock county; at 322,975 feet, or sixty-one miles eight hundred and eighty-five feet, it reaches William Smith's farm, near the Hawesville and Hartford road, in Hancock county. From thence it runs one quarter of a mile north of Hardinsburg, in Breckinridge county; passes two miles north of Boston, in Nelson county; through the spring property at Harrodsburg, and along the north side of Richmond. Said line crosses the Licking river at Licking Station; runs up the Rocky Fork of Burning Spring Fork of Licking; enters Floyd county at the crossing of the Licking; passes into Johnson, crossing many of the branches of Jenny's creek, in that county; intersects the Big Sandy at the mouth of Little Paint creek, near the corner of Johnson and Floyd counties—a distance, altogether, of 278 miles 917 feet, where the work closed in the year 1859.

After Sidney S. Lyon had completed his survey of the eastern boundary of the western coal field, the survey of the base line was resumde

and carried from the corner of Johnson and Floyd counties, through to the Virginia line, making, in all, a distance of 306 miles 1,800 feet.

Since the mode adopted for running the base line by compass necessarily involves unavoidable errors, incidental to the rotundity of the earth's surface and other causes combined, corrections should hereafter be established at important and convenient points, where the latitude and longitude could be taken; as, for instance, at Owensboro, in Daviess county; at Knottsville, in Hancock county; at Hardinsburg, in Breckinridge county; at Boston or Bardstown, in Nelson county; at Harrodsburg, in Mercer county; at Richmond, in Madison county; at the principal crossing of the Kentucky river, below Irvine, in Estill county; at Licking Station, in Morgan county; at the confluence of Big Sandy and Little Paint creek, near the corner of Johnson and Floyd counties; and, finally, at its intersection with the boundary line between Kentucky and Virginia. Thus corrections might be established along this base line after the manner of the correction-lines of the United States land surveys.

The topographical and geographical surveys already instituted, or hereafter to be made, will be laid off north and south from said base line, commencing and closing on the same.

The entire length of this line, from its point of commencement on the Ohio river, in Union county, to its intersection with the east boundary line of Kentucky, in Pike county, is 306 miles 1,800 feet.

To run, chain, and cut out this line, has been, by far, the most expensive part of the detailed survey of the State, since it required a force in the field double that required for the detailed topographical surveys in the individual counties. This great work, now completed, will enable the future surveys to progress more rapidly.

The other two important works accomplished are the surveys which have established the boundaries of the two coal fields of Kentucky. The one survey has been run from a station on the Ohio river, below Greenupsburg, in Greenup county, meandering the outline of the eastern coal field to the Tennessee line. The other survey commenced at a point on the Ohio river, near Hawesville, and meandered the outline of the western coal field, until the terminating line again intersected the Ohio river, near the mouth of Tradewater river.

The meandered outline of the eastern coal field is represented on a small map, executed by the new process of photo-lithography, by which the whole contour and topography of the large manuscript map of this work has been reduced by the camera, and transferred to the stone; which photographic impression served, subsequently, as a substitute for hand drawing or engraving, from which to take impressions off the stone. This map is therefore interesting, not only as representing the exact outline of said coal field, but as a specimen of a new art, just perfected. The topographical maps of Hopkins and Greenup counties, and Carter and Lawrence counties, are now completed, and have been ready for distribution since last year. The map of Hopkins county is already far advanced, and can be prepared in a short time, when means are provided to do so.

In making the surveys necessary to establish these boundary lines, considerable portions of the following counties have been embraced in said surveys: Carter, Rowan, Morgan, Bath, Montgomery, Powell, Estill, Owsley ,Jackson, Rockcastle, Pulaski, Wayne, and Clinton, in the eastern coal field; and Hancock, Breckinridge, Ohio, Grayson, Butler, and Muhlenburg, in the western coal field.

More extended researches have been made into the relative age, equivalency, thickness, range, and extent of the various beds of coal comprised in the coal measures, in further elucidation of, and comparison with, the normal order of superposition, formerly established in Union county; and the Palæontological Assistant has continued and extended his investigations into the specific character of the fossil plants of the roof-shales of each bed of coal; which investigation fully confirms the order of superposition, as formerly given from other evidence, with only one important alteration. It is now demonstrated, that in the western coal field there is no *workable* bed below the Bell or Tradewater coal, No. 1 B of the sections of the Western Kentucky coal measures. Along the valley of Tradewater, and elsewhere, in the western coal field, there is a thin vein, under or between beds of conglomerate, equivalent to the Caseyville Sandstone, of four to six inches in thickness; but it has nowhere been found of workable thickness, and no bed of coal, referred to as the Spigert or Cook coal, can be demonstrated or established as a workable bed *below* the Bell coal and above the Caseyville conglomerate.

Nevertheless, in the eastern coal field, in Rowan, Morgan, Bath, Powell, Estill, and Pulaski counties, one, sometimes two, and even three beds of

coal occur under the conglomerate; all of which underlie what is usually regarded as the productive coal measures. Some of these are thick enough to work, and of a quality equally as good as many of the higher coals. These coals are designated as "*sub-conglomeritic*," as indicating their geological horizon, below the pebbly sandstone which underlies No. 1 coal of this Report.

In the classification of the Pennsylvania coal measures, the 400 feet of strata under the Pittsburg (or our No. 11) coal have been denominated "barren measures," inasmuch as no beds of coal, over one foot in thickness, have been discovered in that subdivision of the coal measures of Pennsylvania. Such a classification is not applicable to the coal formation of Kentucky; since we have in our western coal field in the corresponding space, under our No. 11 coal, no less than four beds, from three to four feet in thickness, besides two others from two to two and a half feet in thickness, while No. 9 coal of the Kentucky Report, in this space, is one of the most persistent, workable beds in the western coal field.

The coal formation of Kentucky is naturally divided, by the interpolation of two conspicuous, important, and generally persistent sandstones, into three subdivisions—an upper, middle, and lower. If any of these subdivisions deserve in Kentucky the name of barren measures, it is the upper—*above* and not below No. 11 coal; since in these higher measures no coal is, at present, known in the State of more than two and a half feet in thickness.

The two prominent sandstones which mark the geological horizons, separating the upper from the middle, and the middle from the lower of the above divisions, are known in the West as the "ANVIL ROCK" and the CURLEW SANDSTONE; the latter, the equivalent of the "*Mahoning Sandstone*," or the *Fifth Great Sandstone* of Lesley. The former seems to have attracted less notice in other States than it has in Kentucky, but is no doubt referable to the "Williamsport Sandstone," of Pennsylvania, and No. 7 of Dr. Hilldreth's section, at Wheeling, given on pages 80 and 81 of the American Journal of Science and Art, vol. 29, No. 1, October, 1835, and No. 2 of section on page 68 of same volume. Each of these divisions, interposed between these prominent sandstones, is about 500 feet in thickness. The lower division of our coal measures, under the Curlew Sandstone, contains four principal coals, numbered from 1 to

4, inclusive; the middle division embraces eight coals, numbered from 5 to 12, inclusive; the upper division includes six coals, numbered from 13 to 18, inclusive.

In Kentucky, the lower and middle divisions are the richest in good workable coals. The most reliable of these, both for uniformity of thickness and extent of area, are Nos. 1, 9, and 11. In the Green River Valley and Hopkins and Union counties, No. 12 attains often a good workable thickness; but occasionally it is only a rash coal; at other times, a reedy coal, well adapted for the manufacture of iron from its ores with *raw* coal.

In Western Kentucky, the principal repository of cannel coal is No. 1 B; but it is only locally so, as at the Breckinridge mines, and in some parts of Hancock and Union counties.

In the eastern coal field of Kentucky, as well as in Pennsylvania, coal No. 3 assumes more frequently the cannel character and chemical composition suitable for the manufacture of coal oils. The lower fifteen inches of this coal, from the Tar-Kiln branch of Stinson creek, in Greenup county, has been analysed by the Chemical Assistant, Dr. Peter, since the publication of the last Report, and found to be richer in oil than any of the Kentucky coals hitherto analyzed, and richer, even, than the celebrated oil coal of Boghead, in Scotland, yielding, as the Tar-Kiln coal does, from 100 to 110 gallons to the ton. The whole bed is three feet thick, with a clay parting of three inches. One foot above the clay parting is bituminous coal; the nine-inch layer below it is cannel, but inferior in quality to the lower fifteen inches of the bed, which is the richest oil-producing coal known, unless it be the Albert coal, of New Brunswick. As I have shown elsewhere, any bed of coal is liable to assume the cannel character wherever there has been a growth of resinous trees to produce it. That kind of growth appears to have been more prevalent, however, in the early part of the carboniferous era.

No. 1 coal is often divided into two members, and even sometimes three members, lying from a few inches or feet to thirty, or even fifty feet apart, and is known in Pennsylvania under the name of "Mammoth Vein," since, in the anthracite region of Carbondale, its united members, A, B, and C, attain a thickness of twenty-five feet; those of Scranton embrace thirty feet, and those of Wilkesbarre no less than forty-seven feet.

In Western Kentucky, No. 1 coal ranges from four to six feet. This coal, the first coal above the conglomerate, is the most reliable, both as to thickness, extent, and persistency, of any bed in the whole range of the coal formation. It is the coal which is mined at the Bell & Casey mines, on Tradewater, in Union county; at Hawesville and Breckinridge, in Hancock county, and many other localities around the margin of the western coal basin.

The geological horizon of the heavy black ferruginous limestone of Hopkins county, which so much resembles, in appearance, black-band iron ore, is now referred by M. Leo Lesquereux to the level of No. 8 coal. In a former Report, it was supposed to be associated with No. 7 coal. Nevertheless, on the Saline river, in Illinois, a near approach to black-band ore occurs above a 4-inch coal, which certainly belongs to the horizon of No. 7.

In Hopkins county, No. 11 coal attains its greatest thickness, being, at some localities, 7 to 8 feet. At McNary's, No. 11 and No. 12 lie close together, and have a united thickness of 11 feet.

In the eastern coal field, none of the coal measures above the level of the Mahoning Sandstone appear to exist. It is only in the southwest part of the western coal field that the series is complete. There, eighteen different beds of coal are recognizable, between the conglomerate and the highest measures observed in the neighborhood of Uniontown.

The united thickness of these eighteen beds is about 43 feet; about 13 feet of this thickness belong to the beds included in the lower subdivision of the coal measures; about 24 feet to the middle division; and 6 feet to the upper. This is the greatest thickness of coal at present known in the coal measures of any of the States, except in the anthracite regions of Pennsylvania heretofore alluded to, where the lower coals are so enormously expanded, that the three members of No. 1 vein alone amount to from 25 to 50 feet; yet, in these regions, no coals are at present known above No. 4, or the horizon of the Mahoning Sandstone. In the western part of Kentucky, where the higher measures come in, as in Union county, Kentucky, though the coals above the horizon of the Anvil Sandstone are somewhat thicker than in Pennsylvania, yet the middle division in Pennsylvania is far less rich in coal, embracing, as it does, from 370 to 380 feet of the, so called, "barren measures" of the Pennsylvania Geologists.

The area of the Eastern Kentucky coal field, as now determined by last year's survey of Topographical Assistant Joseph Lesley, is 8,983 square miles, or 5,749,120 acres; that of the western coal field, as determined by Topographical Assistant Sidney S. Lyon, is 3,888 square miles, or 2,487,820 acres. Kentucky has, therefore, an area in all of 12,871 square miles, or 8,236,940 acres—proving that Kentucky possesses 4,732 *square miles more coal area than Great Britain; nearly four times a greater area than Spain; more than seven times greater than France; and nearly twenty-five times greater than Belgium.*

In the British Islands not less than 31,500,000 tons of coal are raised annually, giving employment to 300,000 people.

Let us see now how the vertical distribution and thickness of the beds of coal in Kentucky compare with those of Great Britain. Since a knowledge of these facts, together with that of the area of the coal fields of Kentucky, as exhibited in the maps of the eastern and western coal fields, is of the greatest importance to the future mining prospects of that State, I have prepared three comparative sections: one exhibiting the 811 feet of the Kentucky coal measures in Union county, extending from the Caseyville conglomerate to the Anvil Sandstone; another of the coal measures, as exposed in the shaft of Saint Anthon's colliery, comprising 801 feet from the "Low Main coal" upwards; and the third, the strata exposed in sinking the Rawdon shaft at Moira colliery, on Ashby Woulds, near Boothorpe, in the parish of Ashby-de-la-Zouch.

Any one at all acquainted with the coal measures of the United States will at once recognize in the so-called "Low Main coal," at the base of both of these English sections, the equivalent of our No. 1 coal of Kentucky and Pennsylvania; like the "Low Main coal" of these sections, it rests on gritstones and conglomerate, below the productive coal beds known, in many parts of Great Britain, by the name of the "Farewell Rock," implying, that after reaching this rock no more coal is found; also, the 1st and 2d "Ryders," and the 14-foot main coal, at the foot of the Rawdon shaft, evidently correspond with the three members designated in M. Leo Lesquereux's sections No. 1 A, No. 1 B, and No. 1 C, and it is probable that in these three members are likewise recognizable the three lower beds of the Anthon section, but lying farther apart, the intervening spaces being 38 feet and 26 feet. The equivalency is further corroborated, as the roof, in both cases, is "grey metal," such as the

Bell coal of Tradewater, and as, in both countries, the upper part of the seam has a peculiar cuboidal structure.

In the "High Main coal" of the Anthon colliery we have, in all probability, the equivalent of our No. 4, that is, of the Curlew coal or Union county, of the Pomeroy coal of Ohio, and the Freeport coal of Pennsylvania; at least, this bed lies very nearly the same distance above the "Low Main coal" as our No. 4 is above No. 1—about 300 feet. The "High Main coal" is next in importance and persistency to the "Low Main coal," just as No. 4 of the lower division of the Kentucky coal measures is next in importance and persistency* to No. 1, and the shales which form the immediate roof surmounted by 36 feet of "Strong White Post," have very much the same character as the shales and sandstone of Curlew Hill, the Pomeroy Sandstone of Ohio, the Mahoning Sandstone of Freeport, in Pennsylvania, or Lesley's *Fifth Great Sandstone*, which sometimes re-inaugurates, as he says, the conglomerates, or, in other words, gives evidence of strong currents and important changes of level going on during the time of its deposition.

In M. Leo Lesquereux's report will be found a full description of the fossil flora of the horizons of coals No. 1 and No. 4, but, unfortunately, we have no means of bringing these in comparison with those of the Low and High Main coals of Great Britain, because nothing has been published on this subject, at least nothing that has come under my observation. The comparison of the stratigraphical palæontology of the two countries would be truly interesting, if it could be brought to bear.

The "Low Main coal" of the Rawdon shaft, as well as that of St. Anthon's mine, attain a thickness of 18 feet 3 inches in the former, and 12 feet 11 inches in the latter, provided the three lower beds in the St. Anthon's shaft represent, as I conceive they do, the three members A, B, and C, of No. 1 coal of this Report; showing that this vein in the English coal field has sometimes a great expansion, as the equivalent beds have in some of the anthracite regions of Pennsylvania. At these localities the "Low Main coal," therefore, exceeds in thickness the corresponding bed in Kentucky; but, on the other hand, it can be reached in these coal districts of England only by sinking shafts 700 to 800 feet deep, whereas, in many parts of Kentucky, it can be worked above

* This bed has not been worked at Curlew Hill, but it has been extensively mined in other places, and it is from this vein, and the Pittsburg, that most of the coal burnt in Cincinnati is obtained.

the drainage of the country, or within 50 to 70 feet below high water of the streams where the mines are located. The High Main coal seems to be, for the most part, one or two feet thicker than our No. 4 coal; but, on the other hand, the former lies also deep in most of the English collieries—400 to 500 feet.

I have not seen any special analyses of the Low and High Main coals of England, therefore I am not able to pronounce upon their comparative values as fuels.

It is, however, in the middle and upper divisions in which the Kentucky coal measures show their superiority over the corresponding English sections, as far as we have been able to compare them.

In the 500 feet above the High Main coal in the Anthon's colliery, there is no coal of more than 1 foot recorded, and the total thickness of all the eight beds put together is only 5 1-2 feet; whereas, in Union county, Kentucky, in the corresponding space above No. 4 coal, there are five beds which range from 3 to 5 feet, and the united thickness of the eight beds, in this space, is 24 feet 9 inches, and two of these are as reliable, both as to extent and uniformity of thickness, as any in the Kentucky basins; indeed, No. 11 of this section is the equivalent of the far-famed Pittsburg bed, known better and more favorably in the West than any other bed of coal; and No. 9 coal, lying about 100 feet below No. 11, in Union county, is the well known Mulford bed, which supplies, at present, most of the steamboats that take in coal both at the Mulford and the Curlew mines, below Shawneetown and above Tradewater. A considerable proportion of the coal found at the various depots on the Mississippi river is this No. 9 coal. Both of these beds are worked to "*the day;*" cars being run, by horizontal or very slightly inclined drifts, into the outcrop of the bed, above high water mark.

The better to appreciate the comparative value of the coal districts of Great Britain and Kentucky, I subjoin the following statistics of some of the more important coal fields of the British Islands:

The southwestern coal district has a length of a hundred miles and a width of nearly twenty miles, diminishing, however, in Pembrokeshire to five miles, forming a kind of double oval basin. In this there are twenty-three beds, with an aggregate thickness of 95 feet; of these, twelve beds only may be regarded as workable, varying from 3 to 9 feet; the remaining eleven beds are from 8 inches to 3 feet.

In the Bristol coal district of this southwestern coal field, there are thirty-seven beds, with an aggregate thickness of about 80 feet; but of these beds only ten may be considered workable—*i. e.* 3 feet and over. These ten beds have a united thickness of about 40 feet. This Bristol coal district has a greater expansion of coal measures than is to be found in almost any of the Welsh coal districts.

The upper sandstone, or shales and coal measure	1,800 feet.
The central sandstones, or "*Pennant Grit*"	1,725 feet.
The lower shales	1,565 feet.
Total	5,090 feet.

The lower of these divisions rests on the so-called "*Farewell Rock*" series, (corresponding to our conglomerates and millstone grits lying at the base of our coal measures,) and has a thickness of 1,000 to 1,200 feet under the Briston coal measures proper.

In the small coal basin of the Forest of Dean, which has a diameter of only about ten miles, there are twenty-seven beds, having an aggregate thickness of 40 feet. But of these there are only two beds over 3 feet, and the united thickness of both is only 8 feet 7 inches.

In the higher coal measures, near Pout-y-pool, at the eastern extremity of the southwestern basin, there are nine beds of coal, with an aggregate thickness of 15 feet, but only two workable beds, with a united thickness of 8 feet 6 inches.

In the coal district which supplies the Plymouth iron works, Merthyr Tydfil, the first coal above the Farewell Rock is but 2 feet 2 inches in thickness.

In this region, which is towards the northeast margin of the southwest basin, there are twenty-five beds of coal in all, the aggregate thickness of which is 40 feet; but of these there are only five workable, the united thickness of which is 21 feet 6 inches.

The Pembrokeshire coal measures embrace only five beds of coal, the thickest of which is only 10 inches; but these coal measures are rich in iron-stones.

In the Maestez coal measures, there are fourteen different beds, the aggregate thickness of which is 44 feet; of these, there are six workable beds, the united thickness of which is 36 feet 6 inches.

The coal measures from the Penllergare beds to the Hugh's seam, near Swansea, there are twenty-six beds, with an aggregate thickness of

57 feet; of which six beds are workable, yielding in all 26 feet 6 inches of coal.

In Glamorganshire, the section of the coal measures at Cefn Crebwr embraces twenty-one beds of coal, having an aggregate thickness of 86 feet; of which eleven beds are workable, yielding 56 feet of coal.

A section of the shales and associate coals above the Farewell Rock, in Montgomeryshire, contains twenty beds of coal, the aggregate thickness of which is 37 feet; but of these, only three are workable, having a united thickness of 16 feet.

The celebrated Newcastle coal field, which supplies more than one third of the entire product of Great Britain, and from which most of the coal burnt in London is obtained, has an area of 700 to 800 square miles. The entire thickness of the measures is 1,620 feet, varying, however, in different parts. The total thickness of the twenty-five coal seams is from 40 to 60 feet, the beds varying from a few inches to 6 feet; but there are seldom more than five seams that are workable, and often not more than one or two exist in one locality.

The most important beds are three in number: the High Main, 6 feet thick, and the Low Main, 6 to 7 feet thick. These lie about 360 feet apart. Between these occurs the Bensham vein, over 3 feet in thickness. There are, however, seven beds below the Low Main, but of inferior quality.

The largest is the "Wickham Street," 6-foot bed; the lowest, the "Rockwell," 3-foot bed; the "Hutton Seam" is also much worked, and is of good quality. The "Low Main" and the "High Main" of the Newcastle coal field do not appear to correspond to the Low Main and High Main of the Ashby-de-la-Zouch coal district; but rather to some of the coals of our middle division. The "Main Post" is most likely the equivalent of our Anvil Sandstone, and the Seven-fathom Sandstone perhaps represents our Curlew Sandstone; but of this there is no certainty, unless we had palæontological evidence to aid in the identification of the strata.

From the preceding data it appears, that in the number and thickness of the beds of workable coal, the Kentucky coal measures are fully equal to the average in the most productive regions of Great Britain, hitherto considered the greatest coal country of the world. Since, in our lower

and middle divisions alone, there are seven workable beds, having a united thickness of 28 feet.

In comparing the areas of the two coal fields of Kentucky (which amount to 12,871 square miles) with the total area of the British coal fields, which, all put together, comprise 8,139 square miles, we find, that in superficial extent, Kentucky has 4,732 square miles, or over one third greater area than Great Britain.

It has been said, and said truly: "From the Grampians to Sussex, and from the German Ocean to the Irish Sea, the predominating geological feature of the British Islands is the carboniferous series, with the most magnificent coal deposits, accessible in every direction. These have been the source of Britain's internal riches, and the great cause of the development of the mechanic arts, which distinguish her above all other countries. Had the granite of the Grampians extended into Sussex, or the chalk of Sussex to the Grampians, the whole course of British history would have been changed. Nineteen of her most important manufacturing cities, which lie upon the new red sandstone, drawing from beneath it coal, iron, and lime—the source of their manufacturing prosperity—in either case, it is probable, would never have existed."

If it is, then, to her mineral resources, and mainly to her coal fields, so productive both in coal and iron ore, that Great Britain owes, more than to any other cause, her present greatness, what a future career is held out for Kentucky, by the geological facts revealed by these surveys, and now recorded in this and the preceding volumes of her Geological Report; provided that the information therein contained is spread before a public of capital and skill, seeking a new country for investments and enterprise in the very minerals which have built up their fortunes in the Old World?

In M. Leo Lesquereux's Report will be found a description of both the geological and geographical distribution of the coal strata in Kentucky, compared with that in Pennsylvania and Ohio, along with numerous details illustrating the various modifications to which they are liable, at different localities of their outcrops, in Kentucky as well as in the above mentioned States.

His able exposition of the palæontology of the various coal horizons will be read with great interest by those versed in that department of science. The facts set forth in that part of his Report, in connection

with the stratigraphical and lithological details, will be of the greatest practical service in leading to the discoveries of valuable beds of coal, yet concealed from view either by the debris of the hillside or by superincumbent layers of rock, of greater or less depth. The parallel table of equivalency which accompanies his Report, gives, in a condensed view, a multitude of observations, the result of years of research, and his experience acquired not only during his investigations in connection with the geological survey of Kentucky, but during his extensive travels in other States. Indeed, the amount of information already on record, in the previous Reports of M. Leo Lesquereux, together with his Report now published in this volume, will form standard matter of reference on all subjects pertaining to the coal measures, since it is by far the most *practically* useful Geological Report on this subject which has ever appeared, not only in the United States, but in any part of the old continent.

Along the line of surveys on the eastern margin of the western coal field, the coal beds are comparatively thin. In some localities, two beds of coal show themselves; in others, only one.

A fine bed of iron ore is reported to have been traced by Sidney S. Lyon, during his surveys defining the eastern limits of the western coal field, through the southeast corner of Breckinridge, and west part of Grayson and Butler counties. In part of Grayson and Butler, he reports two beds of good limonite iron ore. To the north and east these ores seem to be best and thickest, gradually becoming thinner and more sandy to the southwest, where they are hardly workable. In Ohio county, the lower of these beds is reported from 4 to 5 feet thick.

It appears to be the case in the Kentucky coal fields, as well as in those of Great Britain, that the thickest, most extensive, and best iron ores occur towards the base of the coal measures. The hydrated oxides of iron are most prevalent, in Kentucky, at the junction of the millstone grit and sub-carboniferous limestone, and always of best quality when they repose on the limestone or occur in fissures, veins, and cavities in this rock; when in connection with the sandstones of the millstone grit they are apt to be too siliceous.

The total number of miles run by Topographical Assistant Joseph Lesley is 435; and 300 miles have been leveled in meandering the outline of the eastern coal field, which starts from the Ohio river, in

Greenup county, following the outcrop of the lowest members of the coal measures—which produces a very tortuous and zig-zag line—besides circumscribing numerous outliers, passing through Greenup, Carter Rowan, Morgan, Bath, Montgomery, Powell, Estill, Owsley, Jackson, Rockcastle, Pulaski, Wayne, and Clinton counties, to the Tennessee line, at a point about six miles to the southeast of Albany C. H. In order that this line may not only define the boundaries of the eastern coal field, but serve as a fixed and permanent basis for any future surveys required to be made across the great eastern coal field of the State, stations have been carefully made and bench marks cut at the forks of every road, leading to the eastward, so that at every point of departure fixed data exist for the starting of the compass lines and for the continuation of the levels.

Some of the principal results of this survey, as summed up by Topographical Assistant Joseph Lesley, are as follows:

First. The lowest coal extends throughout the whole length of the line; though this lowest bed is, at times, and in many places, but a streak, where it feathers out on the margin of this field, still enough remains, in most cases, to be used for local blacksmithing and for home consumption in the grate.

Second. Southward from Proctor, on the Kentucky river, there are two workable beds of coal, proved to be good for gas-making, the grate, and the manufacture of iron.

Third. Continuous bands of iron ore, more or less thick, accompany these beds of coal, which, at many points, could be worked in high blast furnaces to advantage and profit.

Fourth. The line traverses great bodies of timber, much of which is valuable for transportation to the cities, and much for house-building, tanning, and fencing purposes at home; the principal kinds are chestnut-oak, poplar, hickory, dogwood, yellow and white pine, red cedar, and cherry.

Fifth. The larger rivers cutting transversely across this line could be made the main outlets by which to transport this wealth to market.

Sixth. Though a hilly country, it presents no very serious difficulties in the way of establishing a system of railways.

Seventh. Though the soil of the hills is by no means equal to that of the "*blue grass*" counties, it is yet fair, and susceptible of successful cul-

tivation; and there is sufficient of the better class of soils to supply the demand which would, necessarily, follow the extensive working of the minerals. These hills present unusual advantages as sheep-walks, and, from the luxuriant growth of the native grape, give promise of improvement in that direction. Fruit culture, wherever tried, especially on the tops of the highlands, has been successful.

Eighth. It would be of the greatest importance that these mines of wealth in the eastern coal field should be surveyed out in detail, by carrying on a system of cross lines, all to depart from the base line now established, showing the boundary of the eastern coal field, and running southwestwardly, along the line of the dip of the rocks, in order fully to develop the different beds of coal and iron ore, and whatever other minerals there might be found.

In the eastern coal field there remain to be surveyed, in detail, Lawrence, Powell, Rowan, Monroe, Johnson, Estill, Owen, Breathitt, Floyd, Pike, Letcher, Perry, Rockcastle, Laurel, Clay, Harlan, Knox, Whitley, Wayne, part of Carter and Pulaski, and northeast part of Madison and Bath.

A great deal has, however, been done towards this work, in the course of the topographical surveys made by Joseph Lesley, while running the various lines defining the eastern coal field in Carter, Bath, Powell, Monroe, Estill, Madison, Owen, Rockcastle, Laurel, Pulaski, and Wayne counties.

In the western coal field, there now only remain to be surveyed, in detail, Henderson, Daviess, McLean, Ohio, Butler, and Muhlenburg counties, and a small portion of Hancock county.

The completion of these surveys, in the counties embraced in the two coal fields, is the next most important work required to be made in further prosecution of the Geological Survey of Kentucky.

In the appended reports of M. Leo Lesquereux, Joseph Lesley, and Sidney S. Lyon, will be found full and detailed descriptions of their respective surveys in the two coal fields of Kentucky.

Much more progress could have been made in carrying out the detailed surveys, during the years 1858 and 1859, if the appropriation had not been encumbered with the payment of the outstanding bills for the publication of volumes 2 and 3 of the Geological Reports. The sum

of $7,529 19 of the fund was abstracted to pay these publication bills, the binding bill alone being $4,600.

It was in consequence of this reduction of the appropriation, that there necessarily occurred a deficiency to meet the expenses of working up the materials in the office for preparing this report for publication, vouchers for which service remain still unpaid.

Although the Geological Survey of Kentucky is now so far advanced as to furnish accurate maps of the two coal fields, still, no complete, reliable, final geological map of the entire State can be constructed until detailed surveys are carried through the knobby regions of Salt river, including Marion, Nelson, Bullitt, Jefferson, and part of Oldham counties, in middle Kentucky; together with a corresponding belt in parts of Lewis, Fleming, Bath, Montgomery, Clarke, Madison, Garrard, Lincoln, Casey, Russell, Cumberland, and Monroe counties; and until the boundary lines are surveyed between the blue limestones of Lower Silurian date, and the magnesian limestones of Upper Silurian date, comprising two lines, which commence on the Ohio river—one near the confines of Trimble and Oldham counties; the other near the confines of Lewis and Mason counties—and run in courses more or less meandering, but gradually converging, until they will, probably, be only a fraction of a mile apart, near where the Cumberland river enters the State of Tennessee. This must be the work of after years.

The two great water reservoirs in the geological formations of Kentucky are: *First*, the great sandstone formation at the base of the coal measures, commencing with the conglomerate, pebbly, or coarse sandstones, under No. 1 coal, and extending down to the sub-carboniferous limestone, belonging to the age of the Millstone Grit. *Second*, the great sandstone formation lying below the Kentucky river marble rock, and generally considered of the age of the Calciferous Sand Rock and Potsdam Sandstones of the New York survey.

In both cases the water seems to be held up in the sandstones from the impervious character of the shales, both alternating with the sandstones and forming the sub-strata on which the sandstones repose.

In the first and most recent of these sandstones the water is, generally, so strongly impregnated with salt as to be a profitable brine to work, containing from 25 to 50 pounds of common salt in 100 gallons of water.

In the second, or more ancient of these sandstones, the water is also generally impregnated with salt, to the extent of 600 to 700 grains in a wine gallon—mixed, however, with a variety of other salts and mineral substances.

The following analysis, by Prof. J. Lawrence Smith, of a wine gallon of the Duponts' artesian water, at Louisville, gives a very complete exposition of the composition of one of the most copious supplies of water ever obtained from the Great Lower Sandstone above mentioned:

	GRAINS.
Chloride sodium	621.5204
Chloride calcium	65.7287
Chloride magnesium	14.7757
Chloride potassium	4.2216
Chloride aluminum	1.2149
Chloride lithium	0.1012
Sulphate soda	72.2957
Sulphate lime	29.4342
Sulphate magnesia	77.3382
Sulphate alumina	1.8012
Sulphate potash	3.2248
Bicarbonate soda	2.7264
Bicarbonate lime	5.9915
Bicarbonate magnesia	2.7558
Bicarbonate iron	0.3518
Phosphate soda	1.5415
Iodide magnesium	0.3547
Bromide magnesium	0.4659
Silica	0.8857
Organic matter	0.7082
Loss in analysis	8.1231
	915.5582

GASES IN ONE GALLON.

Sulphuretted hydrogen	2.0050
Carbonic acid	6.1720
Nitrogen	1.3580

Professor J. Lawrence Smith considers this Dupont water very similar to the celebrated Kissingen, of Bavaria, and the Blue Lick water, in Kentucky, of which there is an analysis by Dr. Peter, given in the third volume, page 361, of the Kentucky Geological Report.

The most favorable places in which to obtain good salt water from the sandstones of the millstone grit, are where the lower and middle coal measures are so far depressed beneath the surface, by a gradually dipping and extensive trough or synclinal fold, as to bring No. 11 or 12 coal near the surface. By boring, from this geological horizon into the

depression of such a trough, 1000 to 1200 feet, good strong brines are almost invariably struck, which either overflow or reach within a distance from which the salt water can be pumped to the surface.

In Ohio, excellent guides to determine the position of the first and second brines in these sandstones, are two hard siliceous rocks. The uppermost of these is 8 to 10 feet thick, and the upper salt rock lies 200 feet below it. The lower salt rock lies 450 feet below, or 650 feet below the upper siliceous rock.

The lower hard rock is 40 feet thick, and is 180 feet above the lower salt rock. It is often so hard as to require forty-five days' labor to penetrate it.

These salt-bearing gritstones yield, in some salt regions of this country, from 100,000 to 1,000,000 bushels of salt annually.

In some districts, the red shales that lie beneath the millstone grit also afford good brines.

The great fault that runs adjacent to the Kentucky river, near the boundary of Madison, Garrard, and Jessamine, and which is described in third volume of the Geological Report of Kentucky, on page 75, forms, undoubtedly, the great water barrier, whence flows the water down the slopes of the lower sandstone towards the Falls of Ohio, in such volume and force, that from the Dupont artesian well the outflow is equal to 230 gallons per minute, or about 330,000 gallons in twenty-four hours; the water, rising by its own pressure in pipes, 170 feet above the surface.

The following is a concise view of the thickness of the different geological formations, from the top of the black slate at the base of the knobs, down to and into this water-bearing sandstone, below the birds-eye limestone of Kentucky:

Black lingula, shale or slate, in Jefferson county, about	110 feet.
Falls limestone	75 to 100 feet.
Magnesian and other limestones, with a few feet of gritstones	350 to 400 feet.
Blue fossiliferous limestone and marls, including the Trimble county marble rock	414 feet.
Birds-eye limestone	546 feet.
Water-bearing sandstone, with occasional beds of magnesian limestone, penetrated by the Dupont's boring	541 feet

These thicknesses will afford the most reliable data from which to calculate the depth necessary to bore from any of the above geological horizons to reach the great body of water in the lowest great sand rock of the West, provided the dip, and other circumstances, are favor-

able. But the probabilities are that it will be impregnated with salts and sulphuretted hydrogen gas.

There are, however, other sources of water that may be anticipated locally, at much less depths. For instance, an abundant supply of water is often struck about 250 feet from the top of the black slate, after reaching a hard, cellular, cherty, magnesian limestone, which may either rise to the surface, or within pumping distance. At 280 to 300 feet water may also be anticipated, but usually impregnated with salts and sulphur. At 650 to 700 feet, after the borings are fairly in the blue fossiliferous limestone and marls, the water is usually quite brackish.

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CHAPTER II.

CHEMICAL AND AGRICULTURAL GEOLOGY.

THE SOIL AND ITS ANALYSIS.

In submitting the Chemical Report of Professor Robert Peter of his analyses, made for the Geological Survey of Kentucky during the last two years, it behooves me, as Principal of the Survey, on this occasion to add some remarks, and call the attention of the public to their importance and alue; not only that justice may be done to his extraordinary chemical labors, and for the reputation of the Geological Survey of Kentucky, but more especially to claim for agricultural chemistry that position amongst the exact sciences which has, on several occasions, been denied to it by learned men and even professed chemists; thereby retarding its progress, and creating among many a disbelief as to the possibility of demonstrating the relative fertility of soils by any process at present known.

In order to make myself intelligible, it will be necessary to enter here into some minutiæ, both in regard to the arrangements of the laboratory in which the analyses were carried on, and the mode in which Dr. Peter conducted them; for herein, together with the facilities afforded by his connection with the Geological Survey of Kentucky, and the large number of samples of soils furnished him at one time, lies the secret of his remarkable success and his extensive contributions to agricultural chemistry.

Without a knowledge of the peculiar circumstances under which the work was performed, the amount of Dr. Peter's chemical labor, during the last six years, as Chemical Assistant to the Survey of Kentucky, might appear incredible; for he has, in fact, performed a greater number of *reliable, detailed, practically useful* analyses of soils than any living chemist.

In chemistry, as in all other handicraft occupations, long experience and frequent repetition of manipulations give facility and expertness, not to be attained by any short-hand method. These remarks are particularly applicable to Dr. Peter's case, since he has had a lifetime of

experience in chemical pursuits, both as a most successful teacher of the science as Professor for many years in Transylvania University, and as an adept in manipulation and analyses; especially in soil analyses.

Independent of his analytical labors previous to the year 1854, he has, since his connection with the Geological Survey of Kentucky, completed, with the aid of an assistant, the extraordinary number of 1,126 quantitative chemical analyses, of which 375 are soil analyses, in which, on an average, 12 substances have been separately determined.

Admitting, as I do, that we have a few excellent analytical chemists in this country, yet none have had the same opportunity, or, at least, have thought proper to turn their special attention to the analyses of soils; so that none have had as much experience in this department of analytical chemistry as Dr. Peter.

There are many brilliant intellects in theoretical chemical science who never could submit to the close confinement and mechanical drudgery which such a work as the above involves. It requires a steadiness of purpose, quickness of thought and motion, untiring perseverance, unremitted for months and years, and secluded habits, such as very few individuals can endure. Besides these general qualifications and facilities, there must be, in order to bring about these great practical results, attention given to minor details, such as that no unnecessary steps or movements of the body be made so as to consume time, and that the personal habits of the operator be of such a character as to permit the entire concentration of his faculties on the multiplicity of processes, requiring his unremitting vigilance.

In the operation of weighing, which occupies, perhaps, more time than any other of the manipulations pertaining to soil analyses, much time is saved by having special counterpoises for each platinum crucible and capsule used in ignitions: these are best made of small cylindrical cups of gilt metal, with a brass or platinum wire soldered or screwed to the center of the bottom, and of such length, projecting above the rim of the cup, that it can be conveniently laid hold of with the weighing forceps. This metallic cylinder receives shot of different sizes; the final adjustments being made by clippings of very fine platinum or tin foil. Every time a series of weighings has to be made, the correctness of this counterpoise must be tested; but this is done comparatively quickly, as a clipping of foil added or removed, or a touch with a file on one of the shot, soon

makes the balance true. Having employed this system of special standard counterpoises for fifteen years in my own laboratory, I know that at least nine tenths of the time required by the plan of absolute weighing of crucible and contents can be saved; while, in addition to this, there is much less liability to error, since there are fewer weights to be read off, and, in many cases, the sliding-arm and saddle-weight alone suffice to give the desired amount without handling any weights with the forceps at all.

To save yet more of that important element—*time*—in his numerous weighings, it has been Dr. Peter's practice to use two platinum crucibles at once for his ignitions, so that one might be cooling whilst the other was over the flame of the lamp.

Of course the chemical balance must be the most delicate that art is capable of constructing, turning *distinctly* with the one ten thousandth, or at least with the one five thousandth of the weight of the substance to be analysed, and must be provided with that invaluable contrivance of sliding-arm, carrying saddle-weight, by which all the nice final adjustments are expeditiously made, without the necessity of handling small weights with the forceps. With all these aids, after he has become accustomed to the movements of the beam and its machinery for raising and lowering the knife-edge and steadying the pans, the process of weighing is divested of its tediousness; except that which is essential to the slow movements of all delicate balances.

Further: the reagents constantly in use should be in a case, resting on the working-table, within arm's reach of the operator, and his recording-desk in a drawer of the same table. The sand, water, and steam-baths and drying-oven should be within a few feet of the working-table, as well as the balance-table, to avoid, as already stated, unnecessary steps which take up much time when often repeated, as they are, hundreds of times during the day.

The laboratory must be supplied with a sufficient number of platinum crucibles and capsules, glass beakers, funnels, flasks, tubes, &c., to enable the chemist to put into operation together 20 to 40 different analyses; so that it will never become necessary to wait a single moment for the completion of digestions, filtrations, evaporations, or desiccations.

When so many analyses are conducted at the same time, of course every beaker, funnel, filter, &c., must have not only its appropriate num-

ber, but also a letter or other mark to show at once to what series of analyses it belongs, and every care taken that there will be no possibility of confounding results. With such a number of operations on hand at once, *not a single minute need be lost*; but, at the same time, there is, necessarily, such a continual strain upon the mind and body of the chemist, that unless he has a large share of endurance, patience, and indomitable perseverance, he will soon be fatigued, or, perhaps, disgusted; and this is the reason why so few favor or adopt this system of simultaneous analyses; but by no other plan, nor without availing himself of all aids to economize time, could Dr. Peter ever have accomplished the work he has done for the Kentucky Survey in the last six years.

Before commencing any extensive suite of analyses, the purity of reagents must, of course, be ascertained; since if any require to be purified by redistillation, recrystallization, or otherwise, all these operations should be completed previous to entering on the course of analyses, so as not to interrupt the progress of the work by stopping to purify any required reagent. And here I may mention that there is hardly a single important reagent, such as hydrochloric, nitric, sulphuric, and oxalic acids; ammonia, oxalate of ammonia, carbonate of ammonia, caustic potash, carbonate of potash, even when purchased of the most celebrated houses, as chemically pure, but require purifying in order to make as strictly accurate quantitative analyses as have been made for the Kentucky Geological Survey.

The principal operating room in which Dr. Peter made his analyses is 15 feet square. The working and balance-tables stand within three feet of each other, and the furnace, sand and water-baths, three feet from the former, so that one or two steps suffice to reach all important parts of the different operations in their various stages of progression.

Dr. Peter's son, who acted as his assistant, did most of the crushing and sifting of the soils, as well as the washing of the precipitates on the filters; so that Dr. Peter himself was principally engaged in weighing out the soils, transferring them to their appropriate capsules to be dried, or to the flasks for solution; igniting the precipitates, weighing the same, recording and calculating the results of analyses, adding reagents to solutions, in their various stages of progress, and superintending the final washing of each precipitate in order to be certain that the process was thoroughly done; thus every moment of time with him

was economized, as there was no waiting for precipitates to subside, for evaporations to be completed, or filtrates to pass through their respective filters, so many being under way there were always some ready for the next stage of the analyses.

Without all these necessary aids, all these and other expedients for the saving of time, and without immense self-sacrifice, on the part of the chemist, and a great risk to health; without, also, the necessary talent, long training, and a strong determination to carry through the work, it would be impossible to complete so much chemical work in the same space of time in which it was accomplished.

I hold that the soil analyses made in connection with the Geological Survey of Kentucky, from the years 1854 up to the present time, form the most important contribution ever made to geologico-agricultural chemistry, particularly when we take into consideration the system by which these soils were so carefully selected, viz: with reference not only to the derivative geological formation, but often to the individual members of these formations. Moreover, wherever it was practicable the soils were collected in sets, as explained in the previous volume; No. 1 being the virgin soil; No. 2 the soil from an adjacent old field, ten to fifty years or more in cultivation; No. 3 the subsoil from the old field, and No. 4 the under clay: for the purpose of ascertaining whether the comparative chemical analyses of these soils could not show—

First. The relative proportions of the acids and bases in different soils.

Second. The loss of these by a long series of annual harvests without manure.

Third. The peculiarities of the soils derived from different geological formations.

Fourth. The suitability of a soil for any particular crop.

Fifth. What addition any soil, either uncultivated or cultivated, requires to render it productive and remunerative for any given crop; and, of course, the deficiency in the soil of one or more of the eleven elements determined by chemical analyses.

Sixth. The possibility of comparing the composition of soils from different States and different sections of the Union.

Any one who will take the trouble, carefully and understandingly, to examine the numerous soil analyses in Dr. Peter's Report and his

appended tables, drawn up with so much labor, may soon convince himself that all this can be accomplished.

In twenty-one cases out of seventy-nine, the comparative soil analyses of soil No 1, (the virgin soil,) and soil No. 2, (that from an adjoining old field,) has shown the loss sustained by harvesting a succession of crops without return. Most of the eight exceptions are in situations where the soil of the old field is either based on a subsoil richer in certain ingredients than the original virgin soil, or where the old field is receiving acquisitions by washings from easily decomposing shales or argillo-calcareous shell beds, or where, by annual overflows, or permeation from beneath, alluvial lands are receiving fertilizing saliferous silts. For instance, soil No. 983, from an old field, contains 0.066 more potash than No. 982, the virgin soil, which it evidently derives, either from the subsoil No. 984, which contains 0.078 more potash than No. 982, or else from the decomposition of the greater proportion of clay which must be in the soil of the old field, shown by the larger quantity of alumina recorded.

So in the case of No. 1146, it is evident, that the larger proportion of both potash and phosphoric acid in this, the soil of the old field, than in the virgin soil, No. 1144, is derived from No. 1147, the subsoil, which is richer in these ingredients than either the virgin soil or that of the old field, and from the decomposition of the very large proportion of ferruginous clay in the subsoil, No. 1147.

Again, in the case of No. 1149, where the soil of the old field has more phosphoric acid than No. 1148, this exception is explained by the fact, that the soil of the old field is receiving acquisitions by the comparatively rapid decomposition of the subjacent shell beds, made mention of in the description of the locality where the soil was collected, which more than compensates for the loss sustained by cropping.

A similar explanation is applicable to Nos. 1205 and 1208. The larger proportion of phosphoric acid in the soil of the old field, in the first case, is derived from the subsoil, (1206,) richer in that acid than No. 1204, the virgin soil; and the larger proportion of potash in the latter is evidently derived from the decomposition of ferruginous clays, which exist in larger proportions in the soil of the old field than in the virgin soil.

The increase of 0.030 phosphoric acid in No. 853, the soil of the old

field, has evidently, in this case, been from fresh decomposition of the soil during the seven years in which it lay fallow.

The fractional percentage (0.059) of phosphoric acid in No. 1042 over No. 1041, is most likely derived from 1043, the subsoil, which contains more of that acid than No. 1041.

In the case of No. 813, the 0.032 increase of phosphoric acid over No. 812, the virgin soil, is probably owing to an original difference in the two soils, since, in a mountainous region like that near McCormick's, it is very difficult, if at all practicable, to collect soils for comparison under exactly parallel conditions.

This is probably the case also with No. 885; for the analyses show a much larger proportion of carbonate of lime and oxide of iron and alumina in No. 884 than in No. 885, which proves that the soil, No. 885, has been derived from the disintegration of a different layer of rock than that from which No. 884 was produced; more especially, since No. 886, the subsoil, shows a still larger increase in the proportion of oxide of iron and alumina, and in it there is also more carbonate of lime than in the virgin soil.

The larger proportion of potash in No. 1128, from the old field, has undoubtedly been derived from the decomposition of the large proportion of ferruginous clay which enters into its composition. This soil was taken below the junction of the black shale and magnesian limestones, from the latter of which it, no doubt, derives the 0.291 excess of magnesia over No. 1127.

The small excess of potash in No. 1181, over the virgin soil, No. 1179, is due to the greater proportion of ferruginous clay in No. 1181.

The larger proportion of mineral food of plants in No. 832, over that of No. 831, can only be explained either from original difference in these soils, or from the fact that in many parts of the blue limestone and shell marl formations, of Lower Silurian date, there is so rapid a decomposition of the exposed edges and surface of these strata, that it may keep pace with, and even exceed the removal of the acids and bases by cropping; especially where the soil lies, as it very often does, in valleys surrounded by hills composed of these materials, which every shower of rain washes from the declivities into the low situations; these crumbled earths are rich in mineral fertilizers. It is for this reason

that there has been more difficulty in demonstrating the deterioration of the soils, in old fields, in this geological position, than in any other.

Many of these instances cited are no exception to the general law, which I consider to be now established, that *soil analysis is capable of showing the exhaustion in land of the mineral food of plants by continual cropping;* because, in most of the instances cited, the soil of the old field showed a decided loss of the most essential of the mineral fertilizers; though it might in a few isolated cases show a slight increase of one or two of the constituents; owing to local causes, which I have just explained.

I desire to call the particular attention, not only of the agriculturalists of Kentucky, but also of the whole world, to these results; because we find, in this very age, in this generation, indeed, in this very year, doctrines advocated entirely at variance with the opinion that continual cropping, *necessarily*, exhausts land; and that, too, by leading agriculturalists, by men of extensive practical experience, managers of large estates in England, and men, too, who are well read even in the chemistry of agriculture.

During last year, a work has been published by Alexander Burnett, M. A., Land Agent and member of the Royal Agricultural Society of the Central Farmers' Club, London.

In this work we find the following doctrines most strenuously advocated and maintained by what the author conceives unanswerable arguments and statistics:

That tillage is not only a *substitute* for manure, but that by its means any soil may be brought to its *tillage zero* of productive capability, below which (the same amount of tillage continued) no mode of cropping can reduce it.

And because, in the Rothamsted experiments, on a heavy loam soil, by scarifying and plowing this land, and drilling in wheat, for ten successive years, an average of sixteen bushels of wheat to the acre have been harvested, without the addition of any manure, the very extraordinary conclusion is drawn, and is *considered as fully established, that if the land is kept clean and worked at proper seasons, it is impossible to exhaust this soil below the power of producing sixteen bushels of wheat every year.*

On the same page of this volume, the following passage also occurs:

"Tillage is to be regarded as a means of replenishing the staple with actual materials of fertility, although impalpable to the senses, as a distribution of court-yard dung in the turnip-field, or a top-dressing with special manures."

Further: "that tillage, without the use of any manures, was sufficient to maintain land *in full heart.*"

Dung he seems to consider of little value, except as a means of dividing the soil; for we find him quoting from Tull in support of this view:

"Dung, without tillage, can do very little; with some tillage, does something; with much tillage, pulverizes (*i. e.* fertilizes) the soil in *less time* than tillage can do; but the tillage alone, with more time, can pulverize (fertilize) as well."

And in another part of this work he quotes also from the same author:

"I have made many trials of fine dung on the rows, and, notwithstanding the benefits of it, I have, for these several years past, left it off, finding that a little more hoeing will supply it at a much less expense than that of so small a quantity of manure, and of the hands necessary to lay it on and off the carriage."

"The almost only use of all manure, is the same as of tillage, viz: the pulverization it makes by fermentation, as tillage doth by attrition or contusion."

Many more examples I might bring forward from the same high authority, all tending to persuade the farmer that there is no necessity to manure, if he only tills his soil sufficiently; and that, by this method *alone*, all the elements of fertility are supplied in abundance, even if successive crops of grain be grown on the same ground, without alternation or intermission, year after year, for any length of time.

Whence, then, arises the dissemination of such delusive doctrines and mischievous teachings, tending, as they inevitably must, to encourage the natural repugnance existing among farmers, in this country at least, to go to any trouble and expense in restoring to the soil, in the form of manures, the mineral fertilizers of which they rob it?

Admitting, as I do, the immense benefits which the *present generation* can derive from a thorough tillage of the soil and drilling in the grain, with interculture of the vacant interval during the growth of the crop—and though it may be a fact, that by these processes alone, crops of

wheat may be raised for thirteen years in succession, on certain soils, with an average yield of sixteen bushels to the acre—yet I deny the assertion that this can be done without exhausting the soil; and, further, I deny the proposition that by tillage alone a zero of productive capacity can be attained below which no mode of cropping can reduce it.

The fallacy of these doctrines arises from not understanding the means by which tillage, unaided by manure, can produce, for a limited time, remunerative crops of corn and small grain.

Tillage has the very same effect on soil as alternate thawing and freezing and the vicissitudes of time, only in an increased degree; it disintegrates fresh soil, exposes new surfaces, and brings into requisition, or makes available, the locked-up mineral acids and bases that constitute the mineral food of plants; it increases the porosity of the soil, and gives freer access for the atmospheric elements of plants to enter, either in the gaseous form, or condensed in rain, dew, and snow; thus the otherwise immediately unavailable elements of fertility are more rapidly brought into play, than by the slower processes of nature, which are, however, very apparent during one or two seasons of fallow. Without denying that, by the means above cited, highly remunerative crops can be raised, without the addition of manure by the present generation, we do most emphatically assert that this cannot be done without corresponding abstraction of the essence of fertility of the soil; and that a soil becomes more or less exhausted, according to the weight of the grain and straw removed from that soil; and though additional tillage may be able to keep pace with that exhaustion for thirteen years or longer, according to the nature and richness of the soil, that soil will become, sooner or later, barren for the kind of grain successively harvested: for I may just as well be told, that from a bottle full of water an ounce may be yearly taken, and yet that bottle will remain full without any water being put into it in return, as that wheat may be harvested from the same field, year after year, without addition of manure, and remain as rich in the mineral ("terrestrial") food of palnts as it was originally. And I assert, moreover, that tillage, without manure, greatly hastens the exhaustion of the soil, just in proportion to the now elements which it quickly brings into play for the nourishment of the plant, beyond what would be supplied by ordinary causes in operation.

Another fallacy which the whole argument of the book tends to dis-

seminate is, that the atmospheric fertilizers, which high tillage induces to penetrate the soil, restore to the soil *all* that plants require and abstract from the soil; yet it admits that those that are supplied from the atmosphere are only nitrogenous principles, water, or the elements of water, and carbonic acid; and it advocates strenuously the doctrine, that the *special manure* of plants are the nitrogenous compounds.

Now, the truth is, and has been proved, over and over again in practice, that if the mineral food of plants be absent or deficient in a soil, that even the most potent nitrogenous applications to the land will be unavailing, until the mineral acids and bases are supplied.

When, then, at this very day and hour, we find such arguments held up by leaders of agricultural societies for the guidance of the farmer, is it not high time that something should be done by chemical analyses to counteract the delusive hopes which it holds out to the agricultural community, that land never can wear out or become exhausted if it be only drilled and tilled; for if the farmer is only diligent in these two things, he may grow and harvest the same grain crop for any number of years in succession, pocket a handsome profit, and yet not diminish, even in the smallest degree, the natural fertility of this highly taxed land.

Yet this same author admits, most decidedly, that land may be exhausted; but attributes this exhaustion to deficient tillage, as may be gathered from the following paragraph:

"In fact, the reduction of a piece of ground from fruitfulness to infertility, by over cropping and under tillage, is, of all kinds of evidence, the most palpable that that soil has been emptied, for the time, of its available ingredients of vegetation."

And then goes on to say, that it is for such cases as this that Leibig's well known dictum is applicable, "that in the manurial department of husbandry, the chief object of the farmer ought to be to procure from extraneous sources, and restore to his fields those fertilizing minerals, *i. e. terrestrial* substances, which, removed from thence by the causes above mentioned, could only by that means be restored."

Yet Burnett never seems to dream that the great benefits to be derived by the present generation from high tillage, cannot be obtained without hastening, proportionally, the exhaustion of the soil and drawing upon its future resources.

And, in the face of all this, we find in the appendix to this volume

the report of a debate that took place in the Agricultural Society of which he is a member, on "the system of cultivation upon mixed soils, which, under present circumstances, is most profitable." In which debate it is most distinctly and emphatically proved, that the cause of the almost universal failure of the turnip crop was not attributable, as some supposed, to the use of artificial manures, but to the abstraction of some important element from the soil, by the too frequent growth of turnips; that the soil had, in fact, become "sick of turnips;" and that, so far from artificial manures being the cause of the failure of the turnip crop, they had, in fact, very much tended to keep it "afloat."

Instead, then, of chemists disparaging soil analysis, it should be their pride and aim to endeavor to improve and perfect the methods of performing it which have, since the time of Davy, been so revolutionized that soil analysis has, since then, become almost a new branch of analytical chemistry.

[Since the above Report was penned, Geology and the scientific world at large have sustained an immense loss in the lamented death of the distinguished author. A short obituary notice of him will be appended to the next following Report.] P.

FOURTH CHEMICAL REPORT

OF THE

SOILS, MARLS, ORES, ROCKS, COALS,

IRON FURNACE PRODUCTS, MINERAL WATERS, ETC., ETC.,

OF KENTUCKY,

BY

ROBERT PETER, M. D., etc.,

CHEMICAL ASSISTANT TO THE GEOLOGICAL SURVEY.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., *February* 4th, 1860.

D. D. Owen, M. D.:

DEAR SIR: According to your instructions, I herewith transmit to you the report of the chemical work done in my laboratory, for the Kentucky Geological Survey, since the publication of the third volume.

This report embodies the results of more than five hundred analyses, as follows, viz:

Of soils, &c., from the Lower Silurian group	59	
Of soils, &c., from the Upper Silurian group	23	
Of soils, &c., from the Devonian group	27	
Of soils, &c., from the sub-carboniferous group	32	
Of soils, &c., from the coal measures group	25	
Of soils, &c., from Iowa, Illinois, Minnesota, and Wisconsin	7	
	—	173
Of limestones, hydraulic and common		75
Of iron ores of the limonite variety		75
Of iron ores;—carbonate of iron		25
Of coals		36
Of sandstones, shales, clays, &c.		28
Of iron furnace slags		22
Of pig iron		31
Of mineral waters		20
Of remains of mastodon, &c., &c., &c.		7
Of ashes of various samples of tobacco		30
Of ashes of wheat, Indian corn and cob, wine, &c.		8
		529

In all, five hundred and twenty-nine analyses, made during the past two years of the survey.

The forwarding of the report has been a little delayed by an effort which I have made to reduce its size. Finding, after some fifty pages had been prepared, that it was likely to be quite voluminous, I adopted the plan of *tabulating* the results of the analyses of the soils, ores, &c., &c., which came from the same locality, thus greatly reducing its magni-

tude and facilitating comparison. It was necessary, therefore, to re-write the first portion, according to this plan. I have also, as usual, tabulated all the principal analyses at the end of the report; the soil analyses being arranged according to the geological formations.

You will observe that there is now reported one hundred and seventy-three new analyses of soils, sub-soils, under-clays, and marls, and that of these seven were of soils principally from the northwestern States, made for the purpose of comparing the soils of Kentucky with the primeval soil of that great region; and that our good lands do not suffer in the comparison.

There have now been analyzed, in this laboratory, as many as three hundred and seventy-five soils, sub-soils, &c., &c., principally from this State; and the results, published in the several volumes of our Reports, form a greater body of statistics, as to the chemical composition of soils, than is to be found in any part of the world.

In the course of these soil analyses, a comparison was made in seventy-nine cases of the analysis of the virgin, or uncultivated soil, with that of some from a neighboring field which had been cultivated for a greater or less term of years; and in seventy-one cases out of the seventy-nine it was demonstrable, by the chemical analyses, that the soil of the "old field" had lost more or less of its essential ingredients, which had probably been mainly removed from it in the crops produced. In eight cases only, out of the seventy-nine, did the soil of the "old field" appear richer than the neighboring uncultivated soil; and in several of these cases a rich sub-soil had probably been mixed with the surface soil by the operations of the plow. So that it is evident that *careful chemical analysis may not only show the relative proportions of the grosser materials of the soil—as the sand, clay, oxide of iron, carbonate of lime, &c.—to which it has hitherto been mainly restricted, but is also competent, with the use of proper precautions, to exhibit the relative proportions of the more essential elements conducive to vegetable nourishment—the phosphoric and sulphuric acid, the potash and soda, &c.—which exist in it only in small, and frequently minute, quantities; so as to enable us to detect the influence of the culture of the soil in producing its gradual, but certain, deterioration.*

A gratifying result is exhibited in these soil analyses, also, in the fact that a large proportion of our Kentucky lands are naturally as rich as

any on the continent, and that much of what is commonly denominated poor or thin land, and is consequently very cheap and neglected at present, if properly cultivated, in the light of modern scientific agriculture, and by the energetic use of the necessary capital and labor, might be made as productive as much of the arable lands of Europe, or of the more thickly settled portions of our own country. Large bodies of land, as well as immense deposits of mineral riches, now held much below their value and unappreciated in our State, require only the assistance of judicious *public improvements* to make them highly productive and profitable.

Amongst the limestones analyzed will be found a considerable number from various geological formations which would very probably make good *hydraulic cement*, as their composition is similar to that of known good hydraulic limestones. This kind of limestone is very valuable, and will come more and more into use as the country advances in population. Amongst them will be found, under the head of Jefferson county, a limestone from Indiana, which was used in the construction of the court-house in Louisville, which was found, on examination, to be a good water-lime, and which experience had demonstrated to be unsuited for use as a building-stone, because of its porous and absorbent nature, and its great tendency to scale off under the influence of the atmospheric agents. On the other hand, the *magnesian limestones*, which exist in abundance about Louisville, as well as in various other parts of the State, are amongst the most workable and durable of building stones. In these respects some of the magnesian limestones of the Upper Silurian formation closely resemble that remarkable magnesian limestone which is found amongst the very lowest beds of the Lower Silurian rocks—under the Kentucky and bird's-eye marble—which was used at Lexington in the construction of the Clay monument, and which resembles in composition the Dolomitic marble of the north.

The *limonite* iron ores analyzed are almost uniformly rich and valuable. A large proportion of them were from the furnaces in Crittenden, Livingston, Lyon, and Trigg counties, collected by Mr. John Bartlett; others mainly from the counties in the northeastern coal field. The examination of these ores, as well as of the carbonate of iron ores, the samples of pig iron, and iron furnace slag, will no doubt be of considerable assistance to the iron manufacture. It would appear from the analysis of the slag, or "*cinder*," from the various iron furnaces, that in those of the

southern portion of the State generally, it is the practice to use a smaller relative quantity of limestone in the flux than is employed in the Greenup, Carter, and other furnaces, on the northeastern coal field. It is believed that the tendency of the larger proportion of lime in the flux, within proper limits, is to remove more of those injurious elements, sulphur and phosphorus, from the iron. This is true especially of the former element, sulphur; but some doubt exists as to whether lime alone will carry off the *phosphoric acid* which may be present in the furnace charge, and prevent its reduction to phosphorus, which, by uniting with the iron, as is well known, injures its tenacity, by making it "*cold-short.*"

A highly interesting fact, demonstrated in the analyses of the iron-furnace slags is, that phosphorus, in the form of phosphoric acid, is sometimes carried off in considerable quantity in the "cinder." From the known strong affinity which exists between phosphoric acid and alumina, it is probable that this acid exists in the "cinder" in combination with that earth, and that hence the *presence of aluminous materials, in the furnace charge, is favorable to the production of tough iron from ores containing phosphoric acid.* It is therefore recommended, in smelting many of the limonite ores of the southwestern furnaces—which are found to contain very little alumina, and sometimes a considerable proportion of phosphoric acid—not only to add enough limestone to make the cinder a "*bi-silicate,*" like the cinder of the Greenup furnaces, but also to add to the charge some aluminous materials, such as clay, shale, or other argillaceous substances free from phosphoric acid; to carry off as much as possible of this injurious ingredient. In this manner, it is confidently believed, the toughness of the iron will be increased.

Amongst the coals analyzed were two specimens from Carter county of cannel coal, both from the same region, which exceed even the Breckinridge coal in the production of oil, as they also contain less sulphur and earthy matters than that. The manufacture of oils, paraffine, &c., from cannel coal, has, since this survey commenced, taken a wonderful expansion in this country, and is destined still more to increase as experience in the preparation and use of these valuable products of our cannel coal is acquired. There can be no doubt, from the abundance of good cannel coal in our coal fields, and the large quantity of the oil obtained, that cheap production will cause very extensive consumption; and, when the *heavier oils* obtained in this manufacture, have found their appropriate

application, a large amount of capital and labor will be profitably used in these new species of industry.

Great drawbacks at present on this manufacture are, the great expense incurred in machinery, &c., in experiments to find the best processes, and the difficulty of obtaining a good market for the heavier oils. The first will cure itself in the end; and it may be that ingenious persons will either find extensive uses for the heavy oil, or that by a new process (of graduated destructive distillation, for example,) it may be converted into oil suitable for burning in lamps; which is the most extensive application of the more volatile and fluid coal oils.

The thirty analyses of the ashes of tobacco, from various parts of the State, as well as from Cuba and Florida, were undertaken with a view to ascertain the relationships of this plant to the soil on which it is grown, as well as the influence of the soil on the character of the tobacco. It is hoped that this investigation, which is more extensive than any other published, so far as the writer is informed, may be serviceable to an important branch of agriculture in our State. The same remarks will apply to the examination of the mineral ingredients of wheat, Indian corn, and the fermented juice of the grape. By the latter examination it is shown that vine culture, if judiciously carried on, need not be as exhausting to the soil as the ordinary corn crop. This branch of agriculture, which has extended greatly in our neighboring State, Ohio, is well adapted to this region, and will find very appropriate soil and location on much of our land which is now considered too poor or too hilly for profitable culture in the ordinary farm crops.

The twenty mineral waters examined are mostly from two of our well-known watering places.

Yours, respectfully,

ROBERT PETER.

GENERAL REMARKS ON AGRICULTURE AND ON SOIL ANALYSIS, &c.

Although Kentucky can justly boast of the great mineral wealth contained in the two extensive coal fields within her northeastern and southwestern boundaries, with their immense deposits of iron ores, &c., &c., which have already given a great impetus to the industry, the manufactures, and commerce of our citizens; yet, when we observe the large body of lands in the center of the State, some of which may be classed amongst the richest on the surface of the globe, and reflect that almost the whole area of the State is susceptible of cultivation, in the hands of industrious and enlightened farmers, we cannot fail to be convinced that agriculture is her largest interest and the cultivation of her lands her greatest source of wealth.

That this will continue to be the case as long as her lands yield abundant products for the support of her inhabitants or for exportation, and will cease to be true when they become worn out or unprofitable, so that the harvest no longer repays the labor spent upon the soil, is a fact obvious to the most casual observer; and that the soil may become thus unprofitable in the course of time, has been demonstrated by lamentable experience in the history of large bodies of land on the Atlantic shores of some of the older States, which once enriched the early settlers of this country by their luxuriant growths of tobacco, and large harvests of wheat and corn, and which now, even after a long season of rest, are too poor to repay the labor of the husbandman, and hopelessly sterile without the application to them of imported manures; as it was still more early exemplified in Europe and in Africa, where extensive regions, now worthless wastes, yielded in ancient times abundant harvests of grain for exportation.

This deterioration of the soil, by ordinary cultivation, is beginning to be shown in the rich new lands of the west and northwest of our own continent; on which, according to reliable statistics, the crops within the last ten years have lamentably diminished on the best cultivated lands,

as well as in all parts of our country, where proper care has not been taken to keep up the fertility of the soil; the wheat and corn crops, particularly, being found to be much less on the same extent of ground than formerly. According to J. H. Klippart, Corresponding Secretary of the Ohio State Board of Agriculture, in the preface to his elaborate work, "The Wheat Plant," "Wheat, the staple crop of Ohio"—where scarcely any effort is made to return to the soil the essential elements which are removed from it in the crops—"has been annually diminishing in its yield per acre, and in less than fifty years the average product has been reduced from thirty to less than fifteen bushels per acre, whilst in Great Britain"—by the use of guano, bone dust, super-phosphates, lime, marl, and a more thorough culture—"the yield has increased from sixteen to thirty-six bushels per acre during the same period."* According to Jay, in his "Statistical View of American Agriculture," "in Indiana, the river bottoms, which used to produce an average of sixty bushels of corn to the acre, now yield only forty bushels." Numerous other facts of the kind could be quoted; and we may add, that all who have taken the trouble to collect the statistics on this subject from all parts of the United States, have come to the same conclusion, viz: that under the ordinary system of agriculture in this country, our lands are becoming less fertile, and consequently less profitable to the farmer and to the community than formerly; and thus every year the territory of the nation, on which it depends for food and clothing, undergoes a diminution in value, which, taken in the aggregate, appears immense; rendering labor less productive, and driving population farther and farther west towards the Rocky Mountains. In the same course of events, these new lands, not really richer than were most of those of the older settled regions in their virgin state, will be reduced to the same unprofitable condition, and then by force at last will the husbandman be obliged to study the philosophy of his profession, and to learn the true principles of agriculture,

*This statement of Mr. Klippart is denied in the strongest terms in a review of this work in the Ohio Cultivator, Columbus, Ohio, October 15th, 1859, page 313, in which it is called "a falsehood put forth within the last four years by patent medicine men," &c.; and in an article in the same periodical, November 1st, 1855, headed *Prof. Mapes and the Wheat Crop of Ohio*, in which this statement is called "a favorite scandal of Prof. Mapes," it is asserted—1st. That the average wheat crop of Ohio was *never* thirty bushels per acre; and 2d. That the average per acre of wheat in Ohio amongst the majority of good farmers was never better than at that present time. It is evident that the data quoted by the reviewer are imperfect for either side of the question, and that this statement of Prof. Mapes and Mr. Klippart may not be sufficiently well grounded. But yet the general fact of the gradual deterioration of the soil by thriftless culture, and the consequent diminution of its crops, is unfortunately too widely demonstrated in this country as well as on the older continents.

viz: how to cultivate the soil and enjoy its products without impoverishing it.

That our own soil, in Kentucky, is undergoing this gradual process of deterioration, is fully shown by the comparative analyses detailed in the following pages.

An evil so great as the serious decrease of the profits of labor applied to agriculture, which has so much diminished the intrinsic value of landed property, in many places in the older countries as well as in our own, demands the serious attention of governments and of the people; to discover the cause, and to apply the remedy.

Long experience in agriculture has taught the importance of deep and thorough plowing, of draining, of the proper selection of seeds, and of timely, careful, and clean cultivation, as well as the adaptedness of particular crops to region, locality, soil, and season. It has taught us the advantages of fallow, of rotation of crops, of the uses of green crops, either by plowing in, or by feeding animals and the making of barn-yard manure, for the restoration of tired or worn down fields. Many of the valuable precepts of modern husbandry, verified by long experience as the best for the production of good crops, were indeed known to and followed by the Egyptians, the Greeks, and the Romans; but the constant deterioration of the soil, in all those regions where the crops were permanently removed from the land, to be consumed in a different locality, whether that crop consisted of grain or other vegetable products, or of animals, showed that a perfect system of agriculture has not yet been attained; and that a closer study of the soil and its products than was possible to the ancients is necessary.

The ancient theory, that, with *good cultivation*, the land is inexhaustible, which has brought these disastrous results, is yet maintained, even by some of the leading agricultural authors of Europe, and is practically indorsed by most of the farmers of the world, and especially of this country. In our rich virgin soil, ordinary care in sowing, cultivation, and harvesting, only is necessary to secure good crops, and the partial exhaustion of the soil is scarcely appreciated in the first generation. The farmers, who come after these first, find it advantageous to plow deeper, and to study the rotation of crops and the renovating influence of clover; their successors may be obliged to resort to barn-yard manure, to sub-soil plowing, or may even think it more profitable to

seek *new* lands, rather than to endeavor to renovate the old; whilst the experience of older countries have shown that all the manure which can be made on the much exhausted lands which have been cultivated through a long succession of years, is not sufficient, in many cases, to make them produce profitable crops, with all the labor and skill which may be applied to them, and it becomes evident some extraneous fertilizer must be applied to the worn out soil to enable it again to bear remunerative crops.

In England, and other countries in Europe, as well as in some parts of this country, that something extra was found in plaster of paris, in lime, in marls, in guano, in bone-dust or super-phosphates, in phosphatic mineral substances, in various salts of potash and ammonia, or in the contents of the cess-pools and the water closets; and it has been mainly by such means, aided by improved machinery and management, that the products of the fields and the profits of agriculture, in England particularly, have been wonderfully increased, so that the grain crops have been more than doubled on the same space of ground, within the last fifty years.

A difference of opinion has existed, and much debate arisen, as to the *really essential materials* which are taken from the soil in the cultivated crops, and which must be returned to it to restore its fertility. Some; maintaining the opinion, which was held formerly by Dumas and Boussingault, of France, and still upheld by many agricultural writers of England; contend that the relative proportion of nitrogen, or of ammonia, in a manure, determines its value as a fertilizer, and that the atmospheric elements of vegetables are the only really important ones. Others consider what they denominate "*humus*" to be the true food of plants; whilst others, with Sprengel and Liebig, contend, with a somewhat better logic, that the *fixed* or *mineral* ingredients of crops and manures, such as are found in their ashes when burnt; as the phosphates, lime, the alkalies, &c., are the most important for the consideration of the farmer, because, whilst every different element of the vegetable composition is equally essential to the growth of plants, those which are of a fixed nature, and only to be found in the soil, were to be more carefully husbanded and preserved from waste and loss than those elements which are everywhere abundant in the atmosphere.

It is a question of vital importance to agriculture, and, consequently,

to mankind at large, on which depends the largest and nearest interests of our race, and, as may be understood on reflection, one which can be decided only by the aid of modern science—only by ascertaining the minute composition of the soil, and of the atmospheric agents and water which penetrate and moisten it; of the vegetable and animal bodies produced on it, and of the elementary nature of the food and excretions of plants and animals.

Men of science have, with great activity, thrown themselves into this new field of useful research, and within the last twenty-five years this very important question may be said to be in reality settled. Twenty-five years ago some of the ablest chemists of the world had failed to detect that important ingredient, potash, in soils, and the existence of phosphoric acid in them, or in the rocks whence they were derived, was almost matter of speculation alone; but now careful and minute analyses have been made of many soils in various parts of the world, and the mineral elements of plants of many kinds, and the remarkably constant nature of their ashes, as well as the elementary composition of manures, have been ascertained. Numerous experiments have been made on the growth of plants in pure sand, pure silex, and pure charcoal, &c., with or without the addition of the various materials believed to be essential to their growth—as well as extensive observations in the garden and field with various salts and fertilizing agents—and a body of information has now been obtained which, whilst there yet may be, amongst the imperfectly informed or prejudiced, some warm advocates of the exclusive *humus*, *nitrogen*, or *mineral* theories, has caused the real men of science throughout the world, whatever their supposed partisans may think, to be very much of one opinion upon the subject.

The rational theory, which appears to be based on truth, now generally maintained by men of science throughout the world, is the result of numerous observations and experiments mostly made within the present century, and may be summed up in few words:

All plants and animals are *ultimately* composed of comparatively few elements; of these, some, such as *carbon*, *hydrogen*, *oxygen*, and *nitrogen*, which make up the greater portion of their weight, are derived by vegetables from the atmospheric air and the water which penetrate their tissues, and obtained by animals, directly or indirectly, from vegetable food. The remaining elements, *equally essential to organic existence*, but

found in vegetable and animal bodies in much smaller proportions than the *atmospheric elements* above detailed, are derived, mediately or immediately, from the soil, and have been called, by distinction, their *fixed* or *mineral elements;* these are *potassium, sodium, calcium, magnesium, iron, manganese, phosphorus, sulphur, chlorine, silicon, &c.*, mostly existing in the soil and in organic bodies in the state of the oxides, *potash, soda lime, magnesia, oxides of iron and manganese, silex*, or as *chlorides of potassium* and *sodium, &c.* The phosphorus and sulphur, usually found in the soil and absorbed in the form of salts of their acids (phosphoric acid and sulphuric acid), viz: as phosphates and sulphates, exist, also, in some few organic compounds, uncombined with oxygen.

All these elements, whether from the atmosphere or from the soil, are equally necessary to the formation of organic tissues, animal or vegetable, and the absence of any one of them would be fatal to the growth and development of these living beings; consequently, it would appear to be waste of time to theorize as to the relative importance of any of them. But in *practical agriculture* the case is somewhat different, and the one set of elements—the *fixed* or so-called *mineral elements*—become most worthy of consideration and care, because of the greater danger of their alienation and loss, and the greater difficulty experienced in their restoration.

All living plants can, by the aid of solar light, decompose the water and carbonic acid always present in the atmosphere and penetrating the soil; and it is thus they obtain the *carbon, hydrogen*, and *oxygen* necessary to form their tissues; and reliable experiments show, in the air and in the soil, even the most sterile, enough *nitrogen*, in combination either with hydrogen as ammonia, or with oxygen as nitric acid, to supply the most greedy need of this element by vegetables. Indeed it has been proved that many plants, such as the clover, can even work up the gaseous nitrogen existing in such large proportion in the atmosphere, if indeed all vegetables do not exert this power. The supply of these *atmospheric elements*, then, is constant and inexhaustible. For when these organic bodies decay, or are destroyed by any process, these elements are again restored to the atmosphere, the carbon and the oxygen forming carbonic acid again, and the hydrogen and nitrogen producing water and ammonia, or nitric acid, with the aid of the abundant oxygen of the air, and these compounds, as gases and vapors, ceaselessly penetrate the

atmosphere, according to known physical laws, causing its composition to be uniformly preserved, and insuring to vegetable life, on every inch of the surface of the globe, a constant and abundant supply of these important elements.

But the *potash*, *soda*, *phosphorus*, *sulphur*, *lime*, *magnesia*, &c., &c., exist only in a fixed condition in the soil, and in the rocks from whence it is derived, and, especially the four first mentioned, in only limited and comparatively minute quantities; and they are not certainly re-supplied by any general natural process, when they have once been removed from it; but when they have been taken up, as they continually are, into the tissues of plants, and secondarily, into the composition of the bodies of animals, they are usually, in the common course of the consumption of agricultural products, entirely alienated from the soil and in great measure lost to it forever; and this is, in reality, the great cause of the gradual deterioration of the arable land observable all over the globe where agriculture is carried on according to the ancient methods.

As long as men congregate in towns and cities, and consume, within the limits of a small space, for food for themselves and their domestic animals, for clothing and for fuel and construction, the products of a large extent of country, without returning to the land which supplies them any of the *phosphates*, the *alkalies*, or other essential materials of the soil; which, on the contrary, are constantly lost in the cess-pool and the sewer, or allowed to find their way into the streams, and finally into the sea; so long will the country be gradually impoverished, whatever care may be taken to retard the process by various modes of culture, unless these elements thus withdrawn from the soil be restored to it from some other source. Science has long since demonstrated that no element, nor the millionth part of a grain of matter of any kind, can be destroyed by any known power of nature or of art, whilst it is equally impossible to originate it or to change its nature. The various products of the soil consumed as food are not really destroyed; their *atmospheric elements* escape mainly from the bodies of the persons and animals who consume them, as gaseous and vaporous emanations, from the lungs and the skin; whilst the *fixed* or *mineral* elements pass out of the body in the liquid and solid excretions. That quantity of these fixed materials which enter into the composition of the body at death, is left in the soil which hides its decomposition, which gradually returns the atmospheric elements to

their source; whilst even that portion of the products of the soil which is used as fuel, undergoes the same process, but more quickly, giving its volatile portion to the air in the ascending gases and vapors of the smoke, and leaving the *fixed* elements in its ashes.

As cities will continue to exist and increase, and consume the products of the country, a true system of agriculture, the first principle of which is to maintain the productiveness of the soil, would either provide for the final restoration to the land of all those valuable fixed ingredients which thus accumulate in and around them, or are carried off in the streams into which they are drained, or give it an equivalent quantity of them from some other source.

In China, we are credibly informed, the densely populated land has its fertility perfectly maintained mainly by the former plan alone; and in Belgium, and to some extent in France, the small farms, which are only large enough to support the families which cultivate them, and on which, whilst everything raised is consumed on the place and nothing, or almost nothing, is exported, the careful preservation and application to the soil of all kinds of manures made on it, keeps it constantly in a high state of fertility. The Flemish husbandry has long been noted for its success in this respect. All the fertilizing materials from the dwelling-house, the stable, the barn-yard, or the lane, are collected into a cistern, where they are allowed to undergo a kind of fermentation with an abundance of water, and then the fluid mass, properly diluted, is applied to the land, at appropriate seasons, with very striking results.

But almost insuperable difficulties prevent the practical working of any known plan, in this country or in England, by which the cities may be prevented from draining off the fertilizing elements of the soil of the regions tributary to them, and the nuisances of the towns may be employed to re-enrich the country; and railroads, and other modern improvements, have so facilitated the cheap transportation of agricultural products, that the alienation of the essential elements is greatly increased, as well as the difficulties attending their restoration. The distance between the locality where they are produced and the city where they are consumed being so great, frequently, that the necessity is almost inevitable of looking to some other sources for the supply of the lost mineral elements.

It is fortunate for us that such sources exist, to some extent, in various

parts of the country. The rich, fossiliferous, easily disintegrating limestones and marlstones of the Lower Silurian formation—much of the soft black shales, many of our marls and under-clays, in several regions, contain much potash, soda, sulphur, phosphorus, lime, magnesia; oxides of iron and manganese, and soluble silica. The chemical analyses of the various soils of the State and of these rocks, marls, &c., show their relative adaptiveness, and indicate the possibility of obtaining an available supply of mineral fertilizers in many places; and the more thorough study of the essential mineral elements of crops will enable us finally to apply them judiciously.

But agricultural experience has shown that something more is required than the mere *presence* of the essential elements in the soil to make it fertile; it is necessary, also, that they should be in a *soluble condition*, and in proper proportion, to be available for the nourishment of plants. Hence the opinion has occurred in the minds of some that soil analysis is not of any use in determining the intrinsic value of a soil, or its peculiar adaptiveness to any particular crop. Yet this very fact, that the essential elements of vegetables may exist in an *unavailable* condition in the soil, could not have been demonstrated in any other way than by chemical analysis. Common sense teaches us that although all the elements necessary for the vigorous growth of plants may be present in a locality, yet the failure of certain *conditions* would prove fatal to their development. A soil is just as rich, *per se*, during the severity of the winter months, or at the time of a continued drouth—just as full of the elements of vegetable nutrition when drowned by a surplus of water, either of which conditions would wholly prevent the growth of plants, as when the warmth and genial rains of spring cause vegetation to progress with giant strides on the well-drained surface. But all the showers of April and the stimulating warmth of early summer, would fail to produce a crop on land in which these elements were not to be found. The same soil which, in Ohio or Kentucky, would produce a luxuriant growth of Indian corn, transported to Northern Canada would fail to bear any but a scanty and imperfect growth. For these differences of production the *composition* of the soil is not accountable; and in applying the facts given by soil analyses, all those *conditions* which influence vegetable growth must be taken into consideration. The great business of agriculture is to bring together all the favorable conditions which conduce to the pro-

ductions of large crops, without seriously impoverishing the land; and amongst these a proper mineral composition of the soil is of paramount importance, and indispensable in every climate or situation on the globe.

A great deal has been learnt by experience, and proved by scientific research, as to the best modes of making the essential elements of the soil immediately available for the growth of crops. For example, there is much ground for the high value given to *ammonia* and its salts, in stable manure, guano, poudrette, &c.; because, not only does this alkali and its salts yield the indispensable *nitrogen* to plants, but they are also *solvents*, to some extent, of the earthy *phosphates* and other nutritive mineral materials of the soil, bringing them into a condition favorable for immediate absorption into the tissues of vegetables. The same remarks will apply to the *humus* of some writers. Whilst it is undoubtedly true, as is asserted so strenuously by Liebig, that humus, *per se*, cannot afford any nourishment to plants, yet it must be universally acknowledged that the presence of humus in a soil is highly conducive to its fertility. The term *humus*, as understood by chemists at present, is applied to a mixture of compounds of carbon, hydrogen, and oxygen, and sometimes a little nitrogen, which result from the decomposition of vegetable substances, and which give the dark color to the surface soil called *vegetable mould*. To this humus, or its various derivative compounds, have been applied the terms *humine*, *ulmine*, *geine*, and *humic*, *ulmic*, *geic*, *crenic*, and *apocrenic acids;* none of which substances contain any of the *fixed* or *mineral* elements necessary for vegetable nutrition, when obtained in their separated state by the chemist. But they possess so strong an attraction for potash, soda, lime, magnesia, oxide of iron, &c., &c., that *in the soil* they are always combined with them. They, morever, aid so much in rendering these substances, as well as the phosphates and silica, soluble in water; and, besides, they absorb the gases and vapors, water, and the heat of the sun with such force, that there is much reason for the opinion of Berzelius and others, that *vegetable mould* is the real source of fertility.* On examining the report of the analyses of soils, given in this

* Berzelius says: "Arable soil is a layer of vegetable mould (*terre vegetale*) placed on a layer of earth which does not contain humus. Its fertility depends on the quantity of the latter which it contains. Vegetables diminish constantly the quantity of geine contained in the soil, and when we remove the plants which have vegetated in that earth, as is almost always done with arable land, this in the end becomes exhausted to such a degree that it no longer produces anything. For this reason we manure the soil."—*Berzelius, Traite de Chem., French Ed.*, 1832, *vol.* 6, *p.* 579.

and the preceding volumes of the survey, it will be seen invariably when the sub-soil is poorer in organic matters than the surface soil, that although it is really richer in potash, phosphates, &c., than that, digestion in the carbonated water gives a smaller quantity of *soluble extract* from the sub-soil than is obtained from the surface soil which contains more *humus*. Hence such sub-soils, although proved to be very rich in the essential mineral elements, would be found not to be as fertile, at first, as might be expected from their mineral composition, and would require some time to acquire humus by the decay of vegetables on it, or the application of organic manures, to bring its mineral treasure into a *soluble* or available condition. In this we find *one* reason of the utility of barn-yard manures, and for the plowing in of clover and other green crops; whilst for the want of such applications, to bring the essential elements to a soluble condition, to attract moisture and gases, to give a dark color to the soil, favorable to the absorption of heat from the sun, the *mineral* fertilizers alone have, in many instances, appeared to fail to produce the effects which scientific theory seemed confidently to predict.

The conditions which must combine to produce the great result—plentiful and profitable harvests without disastrous injury to the soil—are therefore numerous. The business of the true agriculturist is, consequently, an elevated one, requiring much more preliminary training than is usually given to it by its followers. A great reform is necessary in regard to it throughout our whole country, to prevent the impending evils which will, in time, certainly follow the gradual deterioration of our arable lands. More attention must be given to the *education* of youths destined for the profession of farming, and the scheme of instruction in general must be modified from the time-honored system, almost exclusively pursued in our colleges and academies, according to which the great advances which have been made in modern science, and its applications to the wants of society, are almost entirely ignored; and the training of the young men of the nation should be more fully adapted to our modern pursuits and the requirements of our modern civilization.

It is hoped and believed that some benefit will be ultimately conferred on the community at large, and on agriculture in particular, by the numerous analyses of soils, sub-soils, under-clays, marls, and of the rocks which underlie them and contribute to their formation, contained in these volumes. A prejudice has arisen as to the utility of this kind of exam-

ination, even in the minds of some of our best agriculturists; for which, however, there is much appearance of reason; so few analyses of this kind have been made, even yet, relatively to the very extensive field to be explored, that it may well be believed that a fair comparison of results necessary to the full establishment of the truth in regard to vegetable nourishment can hardly yet be made; whilst many of those examinations which have been made, have been so imperfectly done, that some of the most essential elements of the soil have not been detected or estimated, and the analyses, therefore, are worse than useless.

The difficulties attending such examinations as these, when they are made with all the precautions necessary to give value to the results, are so great, and the appreciation of their value so limited, especially amongst practical men, who have not all been educated to comprehend even the terms of modern science, that if left to individual enterprise alone, such a work would not be undertaken for ages, as the comparative analyses of the various soils of a State. Yet it is fully demonstrable that through the scientific investigation of the nature of soils, manures, and of the products of our fields, lies the only pathway for further improvement in agriculture; a matter, now and from henceforth, of vital importance to the world; and it is as much the duty of governments and communities to provide for the prosecution of this, as it is to institute surveys and improvements of coasts and harbors, and to establish geographical lines and boundaries. Such information once obtained and published, however abstruse the details may appear to the casual reader, or the imperfectly trained operative, cannot fail in the end to find its appropriate applications.

Such a work, to be eminently useful, must be thorough and exhaustive, and can in no way be so economically carried on as by the patronage of a State, a government, or a community. When a single soil is to be examined, and the exclusive attention of the chemist is given to it, to secure the nicest accuracy in the results, without which all his labors would be worse than useless, one month of time would be little enough for the purpose. One of our most distinguished chemists in the North [see Patent Office Reports, Agriculture, 1858, page 291] emphatically asserts, that whilst it demands from twenty to twenty-five days to execute an accurate soil analysis, "no chemist can properly attend to more than one analysis at a time." But, with due deference to so distinguished

authority, I make bold to assert, as the result of full experience, that, when a large number of soils are collected together at the same time for analysis, with a proper organization of the laboratory and arrangement of the various processes with a view to the saving of time and labor, as many as twenty to twenty-five of these different analyses may be completed within the same space of time, without the slightest neglect of any, or the least sacrifice of accuracy; whilst from twenty to forty different analyses may be in different stages of progress at the same moment, all under the eye of a single experienced analyst. In thus arranging his operations in the laboratory of the Kentucky survey, to effect the largest possible amount of work with the greatest economy of time, labor, and expense, the writer had an eye entirely to the attainment of valuable comparative results, knowing that the true value and utility of such labors can only be established after thorough experience and in a great number of separate examinations. Hence, he has made many other minor and unimportant matters of detail, in common laboratory routine, bend to the great design of completing the greatest possible number of accurate minute analyses. And, as the time of the analyst is usually frittered away in a multitude of small operations, as many of these as possible have been performed simultaneously. His implements have been multiplied to a number sufficient to enable him to digest, filter, ignite, dry, &c., a great number of soils or educts at the same time; his balance and operating table, in continual use, have been placed close to the sand-bath and water-bath, &c., to prevent loss of time in unprofitable motions; and the absence of a separate room for the preservation of the *balance*, has been compensated by very free ventilating flues, so arranged as to carry off any fumes which might injure that delicate instrument, and thus, with the use of fixed counterpoises for his capsules and crucibles, much valuable time has been saved in the numerous weighings. In this manner, with the aid of a young assistant, to perform many of the mechanical operations, a number of minute analyses have been completed, in a given time, which might seem impossible to one who always worked according to the ordinary minor rules of the analytical laboratory; and a great number of valuable results obtained, at a very much smaller expense, than would have been possible, had the investigation been left to individual enterprise alone.

DETERMINATION OF THE PHOSPHORIC ACID IN SOILS, AND SEPARATION OF THE MAGNESIA FROM THE ALKALIES.

Since the publication of the description of the method employed in these soil analyses, (in Vol. III, p. 177 of these Reports,) some improvements have been made in these processes. The use of the molybdate of ammonia for the determination of phosphoric acid, by the process of Sonnenschein, has not met with general approbation amongst chemists, and is liable to great irregularities, unless certain precautions are taken. The description, in Vol. III, of the modification of this process used in my laboratory, is likely to lead to error, especially in the statement that hydrochloric acid is added to the mixture to destroy the ammonia of the test liquid. A certain amount of ammonia, it is well known, is always present in and necessary to the composition of the *yellow molybdo-phosphatic precipitate*, and the presence of any chlorine is very objectionable, by rendering this yellow compound more or less soluble. The precautions to be employed are; first, after having burnt out all the *organic matters* from the soil, which is important, to digest it for a week or ten days at a moderate heat, in an excess of slightly diluted nitric acid, with very little hydrochloric acid added. The filtered solution is now evaporated *nearly to dryness*, at a heat approaching the boiling temperature, with an excess of molybdate of ammonia, (as compared with the phosphoric acid present;) water is then added to the yellow solid residuum, with a little nitric acid, and it is allowed to stand in the cold a few hours, when it is washed on a filter, with a little cold water slightly acidulated with nitric acid. It is now dissolved in ammonia, and the phosphoric acid precipitated with ammonia-sulphate of magnesia. As the yellow precipitate, containing the phosphoric acid, is soluble to some extent in the salts of ammonia, even in the nitrate, the process of Sonnenschein, in which much nitrate of ammonia is present in the test liquid as well as in that which is used for washing the precipitate, is objectionable. This precipitate is also soluble in the chlorides; hence the presence of chlorine must be avoided, and the chlorine, from the little hydrochloric acid used in the original digestion, must be entirely removed by evaporation with the excess of nitric acid. It dissolves in any of the dissolved salts of phosphoric acid, and for this reason an excess of the molybdate of ammonia must be added, (the excess of nitric acid, with the little chlorine present in the acid filtrate, decompose the ammonia which is united with the excess of molybdic

acid, and this latter is left on evaporation, mixed with the yellow precipitate in the solid residuum.) According to Craw, (Silliman's Journal,) this precipitate is also soluble in a solution of the alkaline sulphates, and in sulphuric and nitric acids, and in hot water. A soil containing much sulphuric acid would therefore give irregular results, unless this be first removed. A large excess of water or too much nitric acid should also be avoided in the washing process. With these precautions, it is believed that for the ready estimation of the usually very small amount of phosphoric acid which exists in soils, no process yet discovered is as good as this. In all cases, it is found, however, that a quantity of molybdic acid, varying from one to six per cent. of the weight of the substance, goes down with the ammonia-phosphate of magnesia. This can be mainly separated by solution of it in hydrochloric acid, the addition of hydro-sulphuric acid or sulphide of ammonium, and the re-precipitation of the magnesian phosphate from the filtered liquid.

In the *separation of the alkalies from the magnesia*, as described in Vol. III, it is found, that after washing out the carbonates of potash and soda on the filter, the addition of the diluted sulphuric acid alone fails to separate all the magnesia from the baryta salts present, and that consequently there is too much loss of magnesia, especially in the analyses of magnesian limestones, &c. By first drenching the mixed residue of these two earths with the diluted sulphuric acid, and then pouring into the capsule a little pure nitric acid, and diluting the mixture considerably with warm water, the magnesia is completely dissolved, and the loss avoided.

A SUMMARY

OF THE

CHEMICAL ANALYSES

OF

ORES, ROCKS, SOILS, CLAYS, MARLS, IRON FURNACE PRODUCTS, MINERAL WATERS, &C., &C.,

OF KENTUCKY,

MOSTLY PROCURED BY D. D. OWEN, M. D., PRINCIPAL GEOLOGIST, AND MESSRS. S. S. LYON AND JOSEPH LESLEY, JR., ASSISTANT GEOLOGISTS, AND MESSRS. LESQUEREUX, DOWNIE, AND BARTLETT, AND ANALYZED BY ROBERT PETER, M. D., ETC., CHEMICAL ASSISTANT TO THE STATE GEOLOGICAL SURVEY.

ARRANGED IN THE ALPHABETICAL ORDER OF THE COUNTIES IN WHICH THEY WERE OBTAINED, AND NUMBERED UNIFORMLY WITH THE SPECIMENS DEPOSITED IN THE STATE GEOLOGICAL CABINET, IN THE CAPITOL AT FRANKFORT, KENTUCKY.

BATH COUNTY.

No. 777—LIMONITE. *Labeled "Slate Furnace Ore Bank, four miles southeast of Owingsville, Bath county, Ky.; Clinton Bed of the Upper Silurian formation. (The three following described specimens will make an average.")*

A dense, dark-brown limonite, with a reddish ochreous incrustation. *Specific gravity* 3.514. Powder yellowish-brown.

No. 778—LIMONITE. (*Labeled as above.*)

Resembles the preceding, but contains more cavities lined with dull-yellowish ochreous ore. Powder of a yellowish-brown color.

No. 779—LIMONITE. (*Labeled as above.*)

A porous, friable, dull-yellow limonite, with some layers of dense dark-brown ore, inclosing cavities. The soft portion presents an oolitic appearance, from the presence of numerous small, round, hollow grains. Powder brownish-yellow.

No. 780—LIMONITE. *Labeled "From Old Slate Furnace or Wickliffe Bank, a very thick layer near Slate Creek, Bath county, Ky."*

A dense, dark-brown limonite; in some places softer and more porous; presenting a rounded-granular, or oolitic appearance. Powder of a brownish-buff color.

COMPOSITION OF THESE FOUR LIMONITE ORES, DRIED AT 212° F.

	No. 777.	No. 778.	No. 779.	No. 780.
Oxide of iron	76.680	76.774	52.660	80.520
Alumina	.440	.800	2.642	3.482
Carbonate of lime	none.	none.	a trace.	none.
Magnesia	.685	1.018	.781	.558
Brown oxide of manganese	.580	.680	.580	.220
Phosphoric acid	.886	1.206	.438	.758
Sulphuric acid	.235	.221	.235	.201
Potash	.358	.258	.509	.386
Soda	.197	.202	.230	.132
Silex and insoluble silicates	8.080	7.280	32.780	3.280
Combined water	11.200	11.760	9.300	10.900
Loss	.659	----------	----------	----------
Total	100.000	100.199	100.155	100.437
Moisture, expelled at 217° F.	1.300	1.740	1.900	1.500
Percentage of iron	53.400	53.766	36.878	56.369

These ores are, generally, quite as rich in iron as it is profitable to work in the high furnace. Indeed, Nos. 777, 778, and 780, contain so large a proportion of oxide of iron, and so little of earthy materials for the formation of "*cinder*," that it would be expedient to mix them with poorer ores in the furnace. No. 779, which contains nearly 33 per cent. of silicious matter, and nearly 3 per cent. of alumina, would answer well for this purpose. They are all deficient in lime; but this is easily supplied. The most serious objection to these ores is in the considerable proportion of phosphoric acid which they generally contain; which has a tendency to render the iron brittle which is produced from them, No. 779 is the least objectionable in this respect. The use of a large proportion of lime and pure earthy materials, or clay, in the flux, might somewhat diminish this evil, by carrying off more or less of the phosphoric acid in the *cinder*.

No. 781—PIG IRON. *Labeled "Slate Furnace Pig Iron, Bath county, Kentucky."*

A pretty hard, fine-grained, light-grey iron, which yields with some difficulty to the file. Specific gravity 7.069.

COMPOSITION.

Iron	94.542
Graphite	1.700
Combined carbon	none.
Manganese	.692
Silicon	1.067
Slag	.080
Aluminum	.309
Calcium	trace.
Magnesium	.169
Potassium	.142
Sodium	.050
Phosphorus	.024
Sulphur	.135
Loss	1.030
	100.00

The composition of this iron does not exhibit as large a proportion of phosphorus as might be expected from the ores of Slate furnace. The furnace has not been in operation for some years; but the piece of *hard, white* iron, of which the analysis is given above, was obtained at the old works, and believed to have been smelted there.

No. 782—LIMONITE. *Labeled "Limestone Ore,* (*No.* 7*,) *brought by Mr. H. G. Berry, from the east side of Clear Creek. Clear Creek Furnace,* (*Hunt & Berry,*) *Bath county, Ky.*"

A dark, nearly black, porous, granular ore, with irregular portions of whitish, yellowish, and reddish. It adheres to the tongue. Powder of a reddish-brown, somewhat purplish, color.

No. 783—LIMONITE. *Labeled "Limestone Ore,* (*No.* 9,) *west side of Clear Creek. Clear Creek Furnace, &c. Brought by Mr. H. G. Berry.*")

A dark colored, nearly black, fine granular ore; not adhering to the tongue. Powder of a reddish-brown color. *Specific gravity* 2.841.

No. 784—LIMONITE. *Labeled "Limestone Ore,* (*No.* 5,) *on limestone and under sandstone, east side of Clear Creek. Clear Creek Furnace, &c.* (*Brought by Mr. H. G. Berry.*")

A dense, reddish-brown hæmatite, cellular in parts. Powder of a brownish-yellow color.

No. 785—LIMONITE. *Labeled* ("*No.* 6) *Jones' Bank, fifteen inches thick, east side of Clear Creek. Clear Creek Furnace, &c.* (*Brought by Mr. H. G. Berry.*")

A reddish and yellowish friable ore, exhibiting some dense layers, adhering to the tongue. Powder of a light reddish-brown color.

*The numbers in brackets were attached to these ores by Mr. Berry.

No. 786—LIMONITE. *Labeled "(No. 8,) ten inches thick, above limestone and under sandstone. Clear Creek Furnace, &c. (Brought by Mr. H. G. Berry.")*

A dark, nearly black, fine granular ore, adhering slightly to the tongue. Powder of a reddish-brown color.

COMPOSITION OF THESE FIVE LIMONITE ORES, DRIED AT 212° F.

	No. 782.	No. 783.	No. 784.	No. 785.	No. 786.
Oxide of iron	82.120	70.935	72.886	68.140	64.306
Alumina	.820	.900	.980	2.733	3.080
Carbonate of lime	trace.	trace.	trace.	trace.	trace.
Magnesia	1.010	1.129	.551	1.171	1.003
Brown oxide of manganese	1.340	1.780	.380	1.680	2.440
Phosphoric acid	.220	.505	.694	.247	.374
Sulphuric acid	.386	.290	.283	.336	.290
Potash	.193	.291	.321	.413	.703
Soda	.180	.180	.048	.132	.312
Silex and insoluble silicates	8.980	18.640	11.880	16.080	21.407
Combined water	5.420	5.400	12.200	9.040	6.200
Loss				.028	
Total	100.669	100.050	100.223	100.000	100.115
Moisture, expelled at 212° F.	3.040	2.700	1.200	4.060	3.400
Percentage of iron	57.510	49.677	51.043	47.719	45.034

No. 787—CARBONATE OF IRON. *Labeled "Kidney Ore (No. 1;) bottom of Clear Creek, near Clear Creek Furnace, Bath county, Kentucky." (Brought by Mr. H. G. Berry.)*

A nodule, with an orange-brown exterior surface, and a grey interior; exhibiting a few minute scales of mica. Not adhering to the tongue. *Specific gravity* 3.339. Powder of a grey-buff color.

No. 788—IMPURE CARBONATE OF IRON. *Labeled "(No. 2,) found in the place of Limestone Ores Nos. 3 and 7. Clear Creek Furnace, &c." (Brought by Mr. H. G. Berry.)*

A greenish-grey, friable, sandy rock. Powder of a light grey color.

No. 789—CARBONATE OF IRON. *Labeled "Carbonate of Iron, just above black slate. Clear Creek Furnace, &c." (Obtained by Dr. Owen.)*

Exterior yellowish and reddish-brown; interior dark grey, fine-grained; with a few minute scales of mica. Not adhering to the tongue. *Specific gravity* 3.370.

THE COMPOSITION OF THESE THREE CARBONATES OF IRON, DRIED AT 212° F., IS AS FOLLOWS:

	No. 787.	No. 788.	No. 789.
Carbonate of iron	47.330	44.575	43.716
Oxide of iron	11.888	7.121	3.937
Alumina	4.180	3.520	1.881
Carbonate of lime	5.480	5.280	1.184
Carbonate of magnesia	7.754	7.187	5.903
Carbonate of manganese	1.987	.722	.873
Phosphoric acid	.886	1.120	.499
Sulphuric acid	.475	.338	.303
Potash	.674	.788	.355
Soda	.071	.347	.286
Silex and insoluble silicates	19.580	27.380	40.880
Water and loss	---------	1.622	.183
Total	100.305	100.000	100.000
Moisture, expelled at 212° F.	0.600	0.800	0.300
Percentage of metallic iron	31.192	26.630	23.838

No. 790—LIMONITE. *Labeled "Clear Creek Furnace Ore; above the sub-carboniferous Limestone, Bath county, Ky."* (*Obtained by Dr. Owen.*)

A somewhat coarse-grained and porous limonite. Adheres to the tongue. Powder of a purplish-brown color.

No. 791—LIMONITE. *Labeled "Ore over the Limestone of Clear Creek, Bath county, Ky.* (*To be examined for copper.*") (*Obtained by Dr. Owen.*)

A friable, irregularly cellular ore, of a yellowish-brown color. Incrusted with darker material on some of its surfaces. Adheres slightly to the tongue. Powder of a brownish-yellow color.

No. 792—LIMONITE. *Labeled "From Clear Creek Ore Banks, Bath county, Ky., from above the sub-carboniferous Limestone."* (*Obtained by Dr. Owen.*)

A dense, fine-grained, dark-colored ore. Color generally dark yellowish-brown, with some lighter, dirty-buff colored, thin layers, and some dark-purplish incrustation. Not adhering to the tongue. Powder of a yellowish-brown color.

No. 793—IMPURE LIMONITE. *Labeled "Ore over the Limestone of Clear Creek, Bath county, Ky. To be examined for copper."* (*Obtained by Dr. Owen.*)

A fine-granular ore, easily broken. General color dark reddish-brown; a yellowish and reddish-white material appearing amongst the grains in irregular portions. Powder of a purplish-brown color. Resembles No. 782, (No. 7,) but has not so much diffused whitish material. Adheres to the tongue.

No. 794—LIMONITE. *Labeled "Block Kidney Ore, over the Black Slate, Clear Creek Valley, Bath county, Ky."* (*Obtained by Dr. Owen.*)

COMPOSITION OF THESE FIVE LIMONITES, DRIED AT 212° F.

	No. 790.	No. 791.	No. 792.	No. 793.	No. 794.
Oxide of iron	86.268	65.400	77.580	69.940	38.000
Alumina	.480	4.366	1.600	3.297	3.265
Carbonate of lime	a trace.	trace.	trace.	6.504	1.284
Magnesia	.840	.932	.504	2.556	1.565
Brown oxide of manganese	3.580	.580	.580	1.580	.780
Phosphoric acid	.272	1.014	.720	1.783	1.015
Sulphuric acid	.303	.234	.204	.267	.853
Potash	.220	.656	.386	.828	.583
Soda	.123	.245	.260	.202	.147
Silex and insoluble silicates	2.120	15.080	7.040	7.980	44.880
Combined water	6.000	12.100	11.500	6.200	7.900
Total	100.206	100.607	100.374	100.637	100.272
Moisture, expelled at 212° F.	3.300	2.000	1.400	2.500	1.240
Percentage of metallic iron	60.415	45.800	54.330	48.980	26.612

Those ores, amongst the Clear creek *limonites*, which would probably yield the toughest iron, are Nos. 782, 785, 790, and 786, ranged in the order of their relative freedom from phosphoric acid. Some of these ores, containing more than fifty per cent. of metallic iron, especially No. 790, are almost too rich in metal to be profitably smelted in the high furnace, without the addition of poorer ores, or clay, or other earthy matters, with the limestone used for the flux. Ores Nos. 788, 789, and 794, would answer well for this purpose, if their considerable proportions of phosphoric acid were not objectionable. With a proper selection of fluxing materials, these rich ores would undoubtedly make good tough iron.

The *carbonates* of iron Nos. 787, 788, and 789, all require careful roasting, and contain more phosphoric acid and sulphur than is desirable; for although it is probable much of the latter injurious ingredient might be dissipated by judicious roasting of the ore, and some of the former may be discharged in the cinder, by the use of a large proportion of lime and of some aluminous material, such as clay or poor aluminous ore, yet it is probable that the iron made from ores, which, like the above, contain much phosphorus and sulphur, cannot compare in toughness with that made from a purer mineral. For many purposes to which *cast* iron is applied, however, great toughness, or tenacity, is not required, and the great fluidity of the melted metal which contains much phosphorus makes it run freely and produce sharp castings.

No. 795—IRON. *Labeled "Portion of a Salamander from the bottom of an old furnace hearth. Clear Creek Furnace, Bath county, Ky."*

A flat, rusted, irregular mass of pretty tough iron: presenting quite a brilliant appearance on some of the broken edges; with large shining facets, as though it was crystalline in its structure. It extends under the hammer, and yields easily to the file, like malleable iron, but is rather whiter than most wrought iron. *Specific gravity* 6.912.

COMPOSITION.

Iron	97.060
Graphite	.400
Combined carbon	none.
Manganese	.634
Silicon	.471
Slag	none.
Aluminum	.255
Calcium	trace.
Magnesium	.220
Potassium	.177
Sodium	.140
Phosphorus	.108
Sulphur	.166
Loss	.369
	100.000

This iron has been *de-carbonized*, to a considerable extent, by long fusion in the hearth of the furnace, or by some mismanagement, and consequently became too pasty in consistence to flow out freely. Masses of such iron, chilled in the furnace, are called by the iron men *salamanders*, and frequently cannot be removed without taking down the walls of the furnace.

No. 796—Ferruginous Hydraulic Limestone. *Labeled "(No. 4,) same bed as ore (No. 9,) No. 783; two to three feet thick, west side of Clear Creek. Clear Creek Furnace, &c." (Brought by Mr. H. G. Berry.*

A dull, reddish-buff fine-granular rock; adhering to the tongue. Powder of a buff color. *Specific gravity* 2.704.

No. 797—Ferruginous Magnesian Limestone. *Labeled "Magnesian Limestone of the Clinton Groupe, near Owingsville, Bath county, Ky." (Obtained by Dr. Owen.)*

A dull, dark, dirty buff-colored limestone, with dark infiltrations of oxide of iron amongst the fossils, which are abundant in it, especially a peculiar *entrochite* with lobulated periphery. Powder of a light cinnamon color.

COMPOSITION OF THESE TWO LIMESTONES, DRIED AT 212° F.

	No. 796.	No. 797.
Carbonate of lime	53.240	51.580
Carbonate of magnesia	18.531	28.779
Carbonate of iron	----------	3.095
Oxide of iron	8.020	10.627
Alumina	.620	.280
Carbonate of manganese	----------	.752
Brown oxide of manganese	.380	----------
Phosphoric acid	.117	.592
Sulphuric acid	.633	.235
Potash	.444	.209
Soda	.212	trace.
Silex and insoluble silicates	17.540	1.980
Water and loss	.263	1.671
Total	100.000	100.000
Percentage of lime	29.877	28.580
Percentage of magnesia	8.828	13.700
Moisture, expelled at 212° F.	0.700	0.750

The composition of No. 796 is that of a good hydraulic limestone. This rock would also answer for a flux in the iron furnace, if it did not contain so much sulphuric acid; which would, very probably, injure the quality of the iron smelted with it.

No. 797 contains more magnesia and less silica, &c. Similar limestones to this are described under the head of Fleming county. If this rock contained a little more silex, it would, most probably, prove a good hydraulic limestone. Indeed, some magnesian rocks, containing no more

silica than this, have the reputation of making good *water lime.* Hence it is worthy of trial in this relation.

No. 798—MINERAL WATER. *Labeled "Salt Sulphur Water, from a well ten feet deep, about sixty steps from the main house, Olympian Springs, Bath county, Ky."* (*Sent by the proprietor, Mr. H. Gill.*)

This water contains free *sulphuretted hydrogen gas,* which, however, had been dissipated by carriage: also, free *carbonic acid gas,* of which a thousand parts still contained 0.318 of a part. Evaporated to dryness, one thousand parts of this water left 5.709 parts of *saline matters, dried at* 212° *F.*, which had the following

COMPOSITION, VIZ:

Carbonate of lime	0.239	Held in solution by carbonic acid.
Carbonate of magnesia	.124	
Carbonate of iron	a trace.	
Alumina	a trace.	
Chloride of sodium	2.847	
Chloride of potassium	.183	
Chloride of magnesium	.950	
Sulphate of lime	a trace.	
Bromine and iodine	traces.	
Silica	.018	
Water and loss	1.348	
In 1000 grains of the water	5.709	grains.

A sufficient quantity of the water was not sent to the laboratory to enable me to estimate the quantity of the bromine and iodine; which latter is present in a very minute proportion. A visit to the spring will be necessary to estimate the quantity of sulphuretted hydrogen gas which is contained in the water.

Another occasion will be taken, should the survey be continued to completion, to finish the minute analysis of this very pleasant and valuable mineral water.

No. 799—MINERAL WATER. *Labeled "Black Sulphur Water, from a flowing spring, half a mile south of the main house, Olympian Springs, Bath county, Ky."* (*Sent by Mr. H. Gill.*)

This water, when fresh, contains free *sulphuretted hydrogen* and *carbonic acid* gases; also, a considerable proportion of carbonate of soda, giving it an *alkaline* reaction, especially in the concentrated solution. Evaporated to dryness, one thousand parts of the water left 0.558 of a part of *saline matter,* dried at 212° F., which was found to have the following

COMPOSITION, VIZ:

Carbonate of lime	0.114	Held in solution by carbonic acid.
Carbonate of magnesia	.006	
Carbonate of iron	trace.	
Chloride of sodium	.127	
Carbonate of soda	.254	
Sulphate of potash	.002	
Sulphate of magnesia	.012	
Silica	.043	
In 1000 grains of the water	0·558	of a grain.

A very good alkaline, chalybeate, sulphur water.

No. 800—MINERAL WATER. *Labeled "Epsom Water, from a well ten feet deep, about a half mile northeast from the main house, Olympian Springs, Bath county, Ky."* (*Sent by Mr. H. Gill.*)

One thousand grains of this water, evaporated to dryness, left about seven grains of *saline matter, dried at* 212° *F.*, which was found to have the following

COMPOSITION, VIZ:

Carbonate of lime	0.631	Held in solution by carbonic acid.
Carbonate of magnesia	.218	
Carbonate of iron	a trace.	
Alumina	a trace.	
Chloride of sodium	.830	
Sulphate of magnesia	2.600	
Sulphate of lime	.584	
Sulphate of potash	.041	
Sulphate of soda	1.360	
Sulphate of iron	a trace.	
Silica	.015	
In 1000 grains of the water	6.279	grains.

The free *carbonic acid gas* which the water contains was not estimated, as a portion had doubtless escaped during carriage.

This water resembles, in composition and strength, the strongest waters of the Crab Orchard Springs, in Lincoln county. The principal differences observed are, that this contains rather more chloride of sodium and sulphate of lime, and rather less sulphate of magnesia, than those. It will doubtless prove equally valuable as a medicinal agent. (See analysis of Crab Orchard Springs, &c., &c., in volume 2, of these Geological Reports.)

No. 801—MINERAL WATER. *Labeled "Chalybeate Water from a flowing spring, about half a mile north of the principal building, Olympian Springs, Bath county, Ky."* (*Sent by Mr. H. Gill.*)

This water contains free *carbonic acid gas;* the amount of which was

not estimated, because a portion had doubtless escaped during carriage to the laboratory.

One thousand grains of this water, evaporated to dryness, left *about a third of a grain of saline matter, dried at* 212° *F.*, which was found to have the following

COMPOSITION, VIZ:

Carbonate of lime	0.101	Held in solution by carbonic acid.
Carbonate of magnesia	.022	
Carbonate of iron	not estimated	
Chloride of sodium	.035	
Sulphate of magnesia	.021	
Sulphate of lime	.020	
Sulphate of potash	.070	
Silica	.107	
In 1000 grains of the water	0.376	of a grain.

By reference to the qualitative analysis of this water given in Vol. III, of these Reports, it will be seen that the quantity of saline matters contained in it, always small in amount, varies with the season. Doubtless, most of the mineral springs are more or less affected by long seasons of drought, or of wet weather, making them more or less strong; whilst the *relative* proportions of their saline ingredients may remain measurably unchanged.

No. 802—MINERAL WATER. *Labeled "Salt Water, from a flowing well, twelve feet deep, about a hundred yards from the main building, Olympian Springs, Bath county, Ky."* (*Sent by Mr. H. Gill.*)

The free *carbonic acid gas* present in this water was not estimated.

One thousand grains of the water, evaporated to dryness, left about two thirds of a grain of *saline matter*, dried at 212° F., which had the following

COMPOSITION, VIZ:

Carbonate of lime	0.060	Held in solution by carbonic acid.
Carbonate of magnesia	.039	
Carbonate of iron	.018	
Chloride of sodium	.246	
Carbonate of soda	.163	
Sulphate of soda	.046	
Sulphate of potash	.015	
Sulphate of magnesia	.017	
Silica	.033	
In 1000 grains of the water	0.637	of a grain.

It will be seen, by reference, that the saline ingredients of this water are very similar, in kind and quality, to those in the "Black Sulpur Water, No. 799," previously described. This contains only *carbonic acid*

gas, whilst that has also *sulphuretted hydrogen* gas. This water, like the black sulphur water, is an *alkaline chalybeate.* This contains a little more sulphate of soda and a little less carbonate of soda than that.

No. 803—MINERAL WATER. *Labeled "Mineral Water of unknown properties, (cooking water,) from a well ten feet deep and five feet from the kitchen, Olympian Springs, Bath county, Ky." (Sent by Mr. H. Gill.)*

This water contained free *carbonic acid gas*, the quantity of which was not estimated. One thousand grains, evaporated to dryness, left *more than five grains of saline* matter, dried at 212° F., which had the following

COMPOSITION, VIZ:

Carbonate of lime	0.187	Held in solution by carbonic acid.
Carbonate of magnesia	.105	
Carbonate of iron	a trace.	
Chloride of sodium	4.250	
Chloride of potassium	.059	
Chloride of magnesium	.555	
Carbonate of soda	a trace.	
Sulphate of lime	.012	
Sulphate of potash	.265	
Silica	.037	
In 1000 grains of the water	5.470	grains.

It will be seen that its principal saline ingredient is common salt, (chloride of sodium,) and it is slightly alkaline from the presence of a small quantity of bi-carbonate of soda. The chlorides of potassium and magnesium and the sulphate of potash, together with the carbonates of lime, magnesia, and iron, are usually found associated in salt waters. This is a perfectly wholesome water for culinary purposes; and, properly applied as a remedial agent, in some cases, will prove a valuable addition to the mineral springs of this celebrated watering place.

No. 804—SOIL. *Labeled "Best Hemp Soil, from heavy black walnut land, one and a half miles southwest of Sharpsburg, Bath county, Ky." (Blue limestone of Lower Silurian formation.) Strongest soil of Bath county.*

The dried soil is of a light umber color. Some fragments of ferruginous sandstone were sifted out of it.

One thousand grains of the air-dried soil, digested for about a month in water charged with carbonic acid gas, gave up more than *five grains*

of brown extract; which, dried at 212° F., was found to have the following

COMPOSITION, VIZ:

Organic and volatile matters	1.430
Alumina and oxides of iron and manganese and phosphates	.180
Carbonate of lime	2.663
Magnesia	.193
Sulphuric acid	.045
Potash	.074
Soda	not estimated.
Silica	.114
Loss	.451
Grains	5.150

The air-dried soil lost 4.50 per cent. of *moisture*, when dried at 400° F.

ITS COMPOSITION, DRIED AT 400° F., IS AS FOLLOWS:

Organic and volatile matters	9.527
Alumina	3.990
Oxide of iron	4.235
Carbonate of lime	.620
Magnesia	.700
Brown oxide of manganese	not estimated.
Phosphoric acid	.415
Sulphuric acid	not estimated.
Potash	.290
Soda	.054
Sand and insoluble silicates	80.120
Loss	.049
	100.000

A very good soil, well adapted, by its large amount of soluble nutritious matter, and its considerable proportions of carbonate of lime, phosphoric acid, &c., to the culture of hemp.

No. 805—SOIL. *Labeled "Genuine Clinton Groupe Red Soil, from over the encrinital, flesh-colored, magnesian limestone, (see No.* 797,) *two miles west of Owingsville, Bath county, Ky. Primitive growth, blue ash, sugar-tree, hickory, &c., &c."*

Dried soil of a light reddish-brown color, containing some cherty fragments.

No. 806—SOIL. *Labeled "Same soil as the preceding, from an old field twenty years in cultivation, two miles west of Owingsville, &c."*

The dried soil is of a slightly darker color than the preceding.

No. 807—SOIL. *Labeled "Virgin Soil, from woods, over the gravel ore of the Clinton Groupe, near the Slate Furnace ore, Bath county, Ky."*

The dried soil is of a light, ashy-grey color, containing some duck-shot iron ore, which was sifted out before analysis.

No. 808—SOIL. *Labeled "Soil from a corn-field, over the ore-bed of the Slate Furnace, from a formation of the age of the Clinton Groupe of the New York Geologists, Bath county, Ky."*

Dried soil of a light, greyish-umber color. Some shot iron ore and fragments of red ferruginous sandstone and ferruginous chert, were sifted out of it.

One thousand grains of each of these soils, thoroughly air-dried, were digested, severally, for a month, in water charged with carbonic acid gas. The quantity and composition of the *soluble matters* extracted are represented in the following table:

	No. 805. Virgin soil.	No. 806. Old field.	No. 807. Virgin soil.	No. 808. Old field.
Organic and volatile matters	0.900	0.400	0.700	0.617
Alumina and oxides of iron and manganese and phosphates	.147	.130	.431	.281
Carbonate of lime	1.397	1.563	.430	1.047
Magnesia	.133	.183	.061	.160
Sulphuric acid	.033	.039	.054	.045
Potash	.115	.035	not estim'd	.112
Soda	not estim'd	.057		.038
Silica	.048	.114	.200	.200
Loss	.277	.196	.227	.052
Watery extract, dried at 212° F., (grains)	3.050	2.717	2.103	2.552

The *composition* of these four soils, dried at 400° F., was found to be as follows:

	No. 805. Virgin soil.	No. 806. Old field.	No. 807. Virgin soil.	No. 808. Old field.
Organic and volatile matters	8.165	7.639	5.024	5.118
Alumina	4.565	5.390	3.535	5.115
Oxide of iron	6.960	7.885	3.535	5.150
Carbonate of lime	.570	.420	.095	.170
Magnesia	.710	.615	.385	.523
Brown oxide of manganese	not estim'd	not estim'd	.220	.220
Phosphoric acid	.174	.246	.118	.284
Sulphuric acid	not estim'd	not estim'd	.041	.058
Potash	.290	.249	.246	.210
Soda	.059	.073	.100	.049
Sand and insoluble silicates	79.145	78.270	86.980	83.320
Total	100.638	100.787	100.279	100.217
Moisture, expelled at 400° F.	3.650	3.450	2.475	2.600

These are quite good soils, especially (No. 805,) although probably

not quite as productive as the preceding, (No. 804.) The soil of the old field (No. 806) shows, in the diminution of some of its essential elements, the influence of the twenty years cultivation, as may be seen by comparing together the quantities of *soluble matters* extracted by the carbonated water from that and the virgin soil, as well as the relative proportions of *organic matters, carbonate of lime, magnesia, potash, and soda.* The phosphoric acid appears in larger proportion in the soil of the old field, probably from some admixture of the sub-soil.

No. 809—SOIL. *Labeled "Virgin Soil, from woods pasture; from Mr. Sudduth's farm, a mile and a half east of Sharpsburg, Bath county, Ky. Primitive growth, black locust, black walnut, black and blue ash, and sugar-tree. Some of the best blue limestone land of Bath county. Lower Silurian formation."*

Dried soil of a light umber color. Some fragments of dark, soft, ferruginous sandstone were sifted out of it.

No. 810—SOIL. *Labeled "Same Soil, from an old field, fifty years in cultivation. Mr. Sudduth's farm, &c., &c."*

Dried soil of a light umber color, slightly lighter colored and more yellowish than the preceding. Some shot iron ore was sifted out of it.

No. 811—SOIL. *Labeled "Sub-soil from the same old field," &c., &c.*

Dried soil lighter colored and more yellowish than the preceding.

One thousand grains of each of these soils, thoroughly air-dried, were digested severally, for a month, in water charged with carbonic acid under pressure. The analyses of the *soluble materials,* removed from them by the carbonated water, are given in the following table, viz:

	No. 809. Virgin soil.	No. 810. Old field.	No. 811. Sub-soil.
Organic and volatile matters	1.583	0.710	0.409
Alumina and oxides of iron and manganese and phosphates	.781	.147	.097
Carbonate of lime	3.073	1.597	.963
Magnesia	.200	.770	.120
Sulphuric acid	.045	.045	.056
Potash	.144	.085	.020
Soda	.047	.026	.025
Silica	.214	.314	.200
Loss	.313	----------	----------
Watery extract, dried at 212° F., (grains)	6.400	3.694	1.881

By comparing the following analyses of these soils, it will be seen that the sub-soil is very nearly as rich as the virgin (surface) soil; yet, probably, because the former contains less of *organic matters* and of other materials which act as *solvents* in the soil, it does not give one third as much *soluble* extract to the carbonated water, and would not prove to be as productive as that, without the addition of manures. It will be observed in these reports of the analyses of soils, that it is generally the case that the sub-soil gives up less of soluble matter, to the water charged with carbonic acid, than the surface soil; and always the case when the sub-soil is of a more clayey nature than that. Hence these sub-soils require exposure for some time to the atmospheric agencies, and mixture with *organic matters*, (viz: the remains of decaying vegetable and animal bodies,) before they can readily give up their mineral food to plants. From this it will be understood that these two conditions are necessary to the *fertility* of a soil; *first*, that the proper mineral ingredients for vegetable nourishment exist in it; and, *second*, that they are in a *soluble condition*. The *relative amount* of these mineral ingredients in a soil, other things being equal, represents its entire capability of production, up to complete exhaustion; the quantity of these ingredients which are in a *soluble state* may represent its *immediate productiveness*. Much error has occurred in relation to the value of the chemical analyses of soils from want of attention to these facts alone.

The *composition* of these three soils, from Mr. Sudduth's farm, was found to be as follows; *dried at* 400° *F.:*

	No. 809. Virgin soil.	No. 810. Old field.	No. 811. Sub-soil.
Organic and volatile matters	8.376	6.308	4.108
Alumina	5.115	5.265	5.490
Oxide of iron	2.185	4.235	4.235
Carbonate of lime	.580	.445	.370
Magnesia	.660	.617	.613
Brown oxide of manganese	.195	.295	.295
Phosphoric acid	.365	.295	.312
Sulphuric acid	.084	.067	.055
Potash	.372	.280	.367
Soda	.123	.044	.037
Sand and insoluble silicates	82.595	82.270	84.920
Total	100.650	100.121	100.802
Moisture, expelled at 400° F.	4.200	3.300	2.650

All the mineral ingredients, essential for the nourishment of vegetables, may be observed to have been diminished, in the soil of the old field, by the fifty years cultivation; yet, not as much as might have been expected, probably because a rich sub-soil has been somewhat mixed with it, and has gradually, in accordance with well known laws, sent up some of its soluble materials to supply the deficiencies of the surface soil.

No. 812—SOIL. *Labeled "Virgin Soil, from the Valley of McCormick's Run, Bath county, Ky. Geological position: upper part of the Knobstone formation. (Sub-carboniferous Sandstone.) These soils show debris from the Millstone grit, or conglomerate, limestone, olive sandstone, and of the iron and coal horizon."*

(This and the following soils from Bath county, were collected by Joseph Lesley, jr., Esq.)

The dried soil is of a brownish-grey-buff color, and contains much sand; some in rounded grains; with some spangles of mica.

No. 813—SOIL. *Labeled "Soil from a field about ten years in cultivation; the first year in timothy and clover; ever since in corn. This year's* (1858) *crop yielded forty-five to fifty bushels to the acre. McCormick's Valley, below McCormick's house. Same Geological position as the preceding," &c., &c.*

Dried soil of a light-grey-brown color; rather darker colored than the preceding. Sifted out of it, with the coarse seive, more than half its weight of soft olive-colored and ferruginous sandstone and pebbles from the conglomerate, with fragments of limestone. It also contains much sand, some of the grains of which are rounded.

No. 814—SOIL. *Labeled "Sub-soil of the preceding," &c., &c.*

Dried soil of a brownish-buff color, lighter than the preceding. Like that, it contains more than half its weight of fragments of soft grey and olive sandstone, and pebbles from the conglomerate, and much sand with rounded grains.

No. 815—Soil. *Labeled "Soil from a field nine years in cultivation, (the first two years in corn, then two years in timothy, blue-grass, and clover, since then used for pasture;) from the east hillside of McCormick's Valley, directly above the place of the three preceding soils. Geological position: on the olive-colored sandstone of the knobstone terrace. It contains debris from the sub-carboniferous limestone; the millstone grit and the intervening shales; clay, iron ore, and coal."*

The dried soil is of a greyish-buff color. It contained about one fourth its weight of fragments of ferruginous sandstone; (which were separated before analysis;) but does not contain so much coarse sand as the three preceding soils, being in a state of finer division.

No. 816—Soil. *Labeled "Sub-soil of the preceding, &c., &c., Bath county, Ky."*

The dried soil is of a grey-buff color, lighter than the preceding. About one third of its weight of fragments of shaley sandstone were sifted out of it before it was submitted to analysis.

No. 817—Soil. *Labeled "Soil from the east hillside of McCormick's Valley, from the same field as the two preceding, and from directly above them.* Geological position: *on the sub-carboniferous limestone terrace. A debris from the over-lying limestones, coal, iron ore, shale, and clay strata, along with the conglomerate, or millstone grit."*

Dried soil of a light-greyish-umber color. About one third of its weight of fragments of soft sandstone, &c., &c., were sifted out of it before submitting it to analysis. This soil is in a state of very fine division.

No. 818—Soil. *Labeled "Sub-soil of the preceding, &c., &c., Bath county, Ky."*

Dried soil of a light grey-buff color, much lighter than the preceding. About one third of its weight of fragments of shaley sandstone, &c., &c., were sifted out of it before analysis.

One thousand grains of each of these soils, thoroughly air-dried, were digested, severally, for a month, in water charged under pressure with carbonic acid. The analyses and quantities of the *soluble extract* thus obtained are given in the following table:

	No. 812. Virgin Soil.	No. 813. Old field.	No. 814. Sub-soil.	No. 815. Soil.	No. 816. Sub-soil.	No. 817. Soil.	No. 818. Sub-soil.
Organic & volatile matters	0.640	0.407	0.360	1.617	0.560	1.450	0.417
Alumina & oxides of iron & manganese & phosphates	.563	.187	.173	1.507	.123	.830	.260
Carbonate of lime	1.130	.487	.553	1.073	.130	2.397	.380
Magnesia	.106	.089	.019	.015	.144	.016	.083
Sulphuric acid	.062	.029	.041	.041	.033	.025	.045
Potash	.055	.151	.125	.224	.102	.196	.060
Soda	.060	.038	.046	.005	.033	.065	.075
Silica	.197	.214	.131	.453	.214	.154	.297
Loss	.264	.155	.035	--------	--------	.600	--------
Watery extract, dried at 212° F., (grains)	3.077	1.757	1.483	4.935	1.339	5.733	1.637

The *composition* of these seven soils, from McCormick's Run Valley, dried at 400° F., is given in the following table, viz:

	No. 812. Virgin Soil.	No. 813. Old field.	No. 814. Sub-soil.	No. 815. Soil.	No. 816. Sub soil.	No. 817. Soil.	No. 818. Sub-soil.
Organic & volatile matters	4.251	3.105	2.164	8.198	5.038	10.527	4.418
Alumina	1.515	1.340	1.415	5.490	*6.927	4.240	4.540
Oxide of iron	2.210	3.710	4.435	3.360		2.210	2.660
Carbonate of lime	.195	.095	.080	.220	.07'	.645	.160
Magnesia	.329	.295	.362	.488	.500	.405	.398
Brown oxide of manganese	.130	.110	.170	.220	--------	.295	.415
Phosphoric acid	.095	.127	.095	.179	.144	.223	.144
Sulphuric acid	.033	.033	.028	.076	.033	.050	.025
Potash	.130	.111	.164	.210	.174	.212	.085
Soda	.050	.040	.018	.018	.119	.046	.181
Sand and insoluble silicates	91.095	89.920	92.270	82.745	86.995	81.295	87.720
Loss	--------	1.114	--------	--------	--------	--------	--------
Total	100.033	100.000	101.201	101.204	100.000	100.142	100.746
Moisture, exp'd at 400° F.	1.425	0.975	0.650	3.025	1.750	3.350	1.550

*And oxide of manganese.

The soils from McCormick's Run Valley show considerable variety of composition within a small space. Nos. 815, and 817, appear to be the richest; giving up more soluble matters to the carbonated water, and containing more *potash, phosphoric acid, sulphuric acid, carbonate of lime and magnesia, and organic matters*, than No. 812. These former are in a finer state of division, and contain less sand than the latter, and appear to be more immediately derived from the sub-carboniferous limestone. They are pretty good soils, notwithstanding the large proportion of fragments of soft sandstone which they contain, and no doubt will prove

quite productive with good husbandry. The sub-soils do not appear to be as rich as the surface soils. Hence sub-soil plowing is not likely to prove beneficial.

The productiveness of soil No. 813, compared with its composition, is remarkable; doubtless its very porous nature is favorable to the growth of the Indian corn; a plant which does not require much lime, in which this soil is rather deficient.

Moreover a large proportion of its nutritious mineral ingredients is in a *soluble condition;* for it will be seen, by reference to the composition of the *soluble extract* of this soil, that although the whole quantity dissolved out by the carbonated water does not appear to be relatively great, (only 1.757 grains from the 1000 of the soil,) yet we find in it a considerable proportion of *potash*, and less than the usually large amount of lime and magnesia, which generally make up the greater part of the weight of this extract. Sandy soils always yield up their nutritive ingredients more readily than clay soils, and, therefore, are more quickly exhausted, than the heavier clay or loam soils. Hence they are with more difficulty kept in a fertile condition than the heavier soils; and are said to be *hungry soils*, because of the little durability of the manures applied to them. Soil No. 813, would be doubtless improved by the free application of slacked lime, especially with some plaster of paris and bone earth, animal manures, or other substances containing phosphates; as well as by top-dressing of marl or clay. Most of these soils are deficient in sulphates, hence plaster of paris will have a good effect upon them. By good management and economy of manures, this land might be made and kept quite fertile.

No. 819—Coal. *Labeled "Coal from the Flower Hill Banks,* 28 *inches thick, owned by Morris McCormick, situated about three miles south of the owner's house, on the head waters of Amet's branch of Indian creek, Bath county, Ky."* (*Obtained by Joseph Lesley, jr.*) "Blacksmiths are particularly pleased with this coal."

A pure, shining, pitch-black coal. Very little fibrous coal between the layers, which generally separate with a shining irregular surface, exhibiting many shallow rounded depressions and elevations. Over the spirit lamp it softened somewhat, and agglutinated a little, swelling to a dense coke. *Specific gravity*, 1.288.

PROXIMATE ANALYSIS.

Moisture	2.90	Total volatile matters	40.20
Volatile combustible matters	37.30		
Fixed carbon in the coke	56.50	Dense coke	59.80
Light-grey ashes	3.30		
	100.000		100.000

The percentage of *sulphur* in this coal is 0.806.

ANALYSIS OF THE ASH.

Silica	1.384
Alumina and oxides of iron and manganese	1.380
Lime	a trace.
Magnesia	.566
Sulphuric acid	not estimated.
Potash and soda	traces not estimated.
	3.330

A good, pure, coal, containing but little sulphur, and leaving only a small proportion of ashes.

No. 820—Coal. *Labeled "Lowest Coal, from the new banks, 22 inches thick, just opened by Dr. Cox and Morris McCormick, a mile and a half above the house of Dr. Cox, and one and a quarter miles from the State Road, on State Road Fork of Beaver Creek, Bath county, Ky. Underlies the conglomerate, or millstone grit. The same bed as the Flower Hill Bank on the opposite side of the ridge. Highly approved by blacksmiths."* (*Obtained by Joseph Lesley, jr.*)

A pure, shining, pitch-black, somewhat soft, coal; having much fibrous coal between the layers. Over the spirit lamp it softens somewhat, and swells into a moderately dense coke. Resembles the preceding. *Specific gravity* 1.288.

PROXIMATE ANALYSIS.

Moisture	5.30	Total volatile matters	41.14
Volatile combustible matters	35.84		
Fixed carbon in the coke	55.80	Moderately dense coke	58.86
Light greyish-white ashes	3.06		
	100.000		100.000

Total percentage of *sulphur* is only 0.672 per cent.

ANALYSIS OF THE ASH.

Silica	1.594
Alumina and oxides of iron and manganese	1.280
Lime	a trace.
Magnesia	.313
Sulphuric acid	not estimated.
Potash and soda	traces not estimated.
	3.187

Very similar to the preceding; containing more fibrous coal between the layers than the preceding, and hence probably is more *hygroscopic.*

No. 821—Coal. *Labeled "Coal from the 'Big Bank,' near tan-yard, on the head waters of Indian Creek, Bath county, Ky. Bed two feet nine inches thick, and described by Dr. Owen, in Vol. III, page* 132, *of his Report."* (*Obtained by Joseph Lesley, jr.*)

A moderately dull, pitch-black coal; rather tough on the cross fracture, but easily cleaving into thin layers, which are coated with fibrous coal, presenting impressions of slender pointed leaves, &c. Over the spirit lamp it did not soften much, leaving a dense coke. *Specific gravity* 1.268.

PROXIMATE ANALYSIS.

Moisture	2.30	Total volatile matters	42.40
Volatile combustible matters	40.10		
Fixed carbon in the coke	53.86	Dense coke	57.60
Dark, purplish-grey ashes	3.74		
	100.00		100.00

The percentage of *sulphur* in this coal is 2.532.

ANALYSIS OF THE ASH.

Silica	0.484
Alumina and oxides of iron and manganese	2.480
Lime	a trace.
Magnesia	.299
Sulphuric acid	.235
Potash	.270
Soda	.187
	3.955

The excess in the ash analysis may be partly due to the oxidation of sulphuret of iron into sulphuric acid and peroxide of iron. It is probable also that the alkalies are a little over-estimated. A considerable number of analyses have been made of coal ashes, however, and in every instance notable quantities of alkalies are found in them, as well as more or less of earthy phosphates. The value of coal ashes as manure, on heavy clay land especially, is greater than is generally believed.

This coal resembles the two preceding, but contains much more sulphur than they.

BOURBON COUNTY.

No. 822—MAGNESIAN LIMESTONE. *Labeled "Loose slab on the surface of woods pasture, where the soil was collected, at William Buckner's farm, Cane Ridge, Bourbon county, Ky." Lower Silurian formation. (See No. 574 of Chemical Report, Volume III.)*

A fine-granular, grey-buff rock, with numerous pores filled with darker buff material. Powder of a light grey-buff color.

Dried at 212° F., the powdered rock lost 0.24 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	75.980	—43.637 lime.
Carbonate of magnesia	15.595	— 7.426 magnesia.
Alumina, and oxides of iron and manganese	4.660	
Phosphoric acid	.822	
Sulphuric acid	.427	
Potash	.165	
Soda	.042	
Silicious residuum	2.640	
	100.331	

BRACKEN COUNTY.

No. 823—SALT WATER. *"On Big Bracken Creek, Bracken county, Ky. (Bottled up a year, but not diminished by evaporation.) Sent by L. G. Bradford, Esq."*

The cork of the bottle containing the water was slightly blackened, as from the presence of a little salt of iron. No sediment in the bottle. *Specific gravity*, by areometers, about 1.014.

Saline contents, about 1.7 per cent., having the following

COMPOSITION, VIZ:

Carbonates of lime and magnesia, with traces of oxide of iron and sulphate of lime	0.0257
Chloride of sodium, (common salt)	1.1835
Chloride of calcium	.0800
Chloride of magnesium	.3140
Silica	.0009
Water and loss	.0959
	1.7000

Too weak to be profitably evaporated for salt.

No. 824—SANDSTONE. *Labeled "Mudstone, on the road from Dover to Augusta, Bracken county, Ky. Lower Silurian formation."*

A grey-buff, impure, sandstone, easily broken; imperfectly and irregularly laminated; with many impressions of bi-valve fossil shells; adheres slightly to the tongue; powder of a light buff color.

Dried at 212° it lost 0.80 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	88.580
Alumina, and oxides of iron and manganese	6.460
Carbonate of lime	.920
Magnesia	.899
Phosphoric acid	.438
Sulphuric acid	.200
Potash	.560
Soda	.166
Water, expelled at a red heat	1.900
	100.123

Resembles the other specimens of mudstone from the Lower Silurian formation which have been analyzed; as reported in the preceding volumes of these Reports.

No. 825—LIMESTONE. *Labeled "Encrinital Limestone from near Augusta, Bracken county, Ky., where the virgin tobacco soil was collected; (see next number.) Lower Silurian formation."*

A coarse-granular, grey limestone; on the weathered surfaces appearing to be almost entirely made up of small *entrochites*, with a few fragments of *Chætetes lycoperdon, &c.*

Dried at 212°, it gave up 0.30 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	91.040	—51.084 lime
Carbonate of magnesia	3.678	
Alumina and oxides of iron and manganese	1.660	
Phosphoric acid	.182	
Sulphuric acid	.269	
Potash	.200	
Soda	.148	
Silicious residuum	2.880	
	100.057	

No. 826—SOIL. *Labeled "Virgin Tobacco Soil; hillside, north exposure, near Augusta, Bracken county, Ky., on Mr. L. J. Bradford's land."* (Obtained by Dr. Owen.) *Lower Silurian formation.*

Air-dried soil of a light umber color.

No. 827—SOIL. *Labeled "Sub-soil, from the hillside, where the virgin tobacco soil was collected, near Augusta, Bracken county, Ky."*

Dried soil of a light dirty-buff color.

No. 828—SOIL. *Labeled "Soil of Tobacco Land, exhausted by successive crops, from the farm of Col. L. J. Bradford, near Locust Creek, Bracken county, Ky. (Sent by Col. Bradford.")*

Dried soil of a dirty-buff color, intermediate in shade to the two pre-

ceding soils. A few fragments of soft, slatey, ferruginous sandstone were sifted out of it.

One thousand grains of each of these tobacco soils, thoroughly air-dried, were digested for a month, severally, in water charged with carbonic acid under pressure. The quantity and *composition* of the *soluble matters* extracted from each by this process, are shown in the following table.

	No. 826. Virgin soil.	No. 827. Sub-soil.	No. 828. Exhausted soil.
Organic and volatile matters	2.250	0.470	0.585
Alumina and oxides of iron and manganese and phosphates	1.063	.130	.147
Carbonate of lime	5.420	.447	1.573
Magnesia	.649	.133	.591
Sulphuric acid	.061	.040	.073
Potash	.104	.048	.071
Soda	trace.	.037	.011
Silica	.314	.149	.147
Loss	----------	----------	.135
Watery extract, dried at 212° F., (grains)	9.861	1.454	3.333

The *composition* of these soils, dried at 400° F., is as follows:

	No. 826. Virgin soil.	No. 827 Sub-soil.	No. 828. Exhausted soil.
Organic and volatile matters	7.981	4.853	5.489
Alumina	6.645	3.680	4.080
Oxide of iron	6.825	5.540	3.215
Carbonate of lime	1.566	.396	.471
Magnesia	1.354	.844	.762
Brown oxide of manganese	.296	.146	.196
Phosphoric acid	.342	.179	.260
Sulphuric acid	.110	.031	.042
Potash	.758	.458	.265
Soda	.047	not estim'd	.029
Sand and insoluble silicates	72.920	83.310	85.300
Loss	1.136	.563	----------
Total	100.000	100.000	100.109
Moisture, expelled at 400° F.	6.975	2.950	2.525

On comparing this "exhausted" soil with the virgin soil of the same locality, some marked points of difference may be observed between them. In the first place, the quantity of *watery extract*, dissolved out of the soils by digestion in water charged with carbonic acid, is greatly larger from the virgin soil than from the "exhausted soil;" being

9.861 grains from the thousand; equal to twenty-nine thousand five hundred and eighty-three pounds (29,583 lbs.) to the acre in the former case; calculating the weight of the soil on an acre of ground, to the depth of one foot, as equal to three millions of pounds (3,000,000 lbs.;) whilst from the latter soil it is only 3.333 grains to the thousand of soil; equal to nine hundred and ninety-nine pounds (9,999 lbs.) to the acre. In this watery extract, dissolved by the carbonated water from the soil, we find, moreover, that the *potash* and *lime*, as well as the *organic matters*, are greatly reduced in that from the exhausted soil, as compared with that from the virgin soil.

The same reduction, in the proportions of the *essential* ingredients of the soil, may be observed in the general analyses of these two samples. The *organic matters*, the *lime*, the *magnesia*, the *phosphoric and sulphuric acids, the potash, and soda,* are all greatly reduced in quantity in the "exhausted" soil, as compared with that which has not been cultivated. We may sum up these differences, as calculated for one foot depth of soil on an acre, taking the weight of this quantity at three millions of pounds avoirdupois, as follows:

	In virgin soil. Pounds.	In exhausted soil. Pounds.	Difference. Pounds.
Organic and volatile matters	239,430	164,670	74,760
Carbonate of lime	47,580	14,130	33,450
Magnesia	40,620	22,860	17,760
Phosphoric acid	10,260	7,800	2,460
Sulphuric acid	3,300	1,260	2,040
Potash	22,740	7,950	4,790
Soda	1,410	870	540
Extract, dissolved by carbonated water	29,583	9,999	19,584

During the progress of this survey analyses were made of the ashes of thirty different specimens of tobacco, with the object of ascertaining the nature of the exhausting action of this crop upon the soil, as well as the influence of the soil upon the quality of the tobacco grown on it, &c. A full detail of the results will be found in the appendix to this Report. It will be seen, on examination, that the tobacco plant withdraws a large quantity of mineral matter from the soil, and especially more *potash* and *lime* than any other ingredients. Probably no vegetable exceeds it in this respect. It is a plant which also requires a very large proportion of nitrogen.

Taking the average of the analyses of the Mason county and Bracken county tobacco examined, as given in the appendix; we find the following results as to the *composition of the ashes;* representing the *mineral ingredients* of the plant, which are necessarily withdrawn by it from the soil.

The table shows the quantities contained in one hundred parts of the air-dried tobacco leaf, viz:

Potash	5·23
Soda	.51
Lime	5.10
Magnesia	.65
Oxides of iron and manganese	.05
Phosphoric acid	.61
Sulphuric acid	.63
Chlorine	.08
Silica	.44
Carbonic acid and loss	4.90
Ash, in 100 parts of air-dried leaf	18.20 parts.

Or a little more than eighteen per cent. of ash, or mineral material, in the dried tobacco leaf.

Taking the average crop of tobacco at one thousand pounds, and adding one third more for the stalks, &c., removed from the land, the quantities of the essential mineral ingredients of the soil removed from the acre, in one year, by this crop may, be represented as follows:

	Pounds.	
Potash	69.73	
Soda	6.80	
Lime	68.00	equal to 121.17 pounds carbonate of lime.
Magnesia	8.67	
Phosphoric acid	8.13	
Sulphuric acid	8.40	
Chlorine	1.06	
Silica	5.86	

It may be interesting to compare, in this place, the quantities of these essential mineral substances taken from the ground in average crops of wheat, Indian corn, and tobacco, as based on the analyses of the ashes of these grains to be found also in the appendix to this Report.

Taking the average wheat crop at twenty bushels of 60 pounds to the acre; the average corn crop at fifty bushels of 56 pounds, and the above datum of the tobacco crop, we have the following results; disregarding the straw, stalks, cobs, &c., &c.:

	In a wheat crop of 20 bushels. Pounds.	In a corn crop of 50 bushels. Pounds.	In a tobacco crop of 1000 lbs. Pounds.
Potash	5.45	8.06	69.73
Soda	.13	6.22	6.80
Lime	1.63	.22	*68.00
Magnesia	2.43	3.61	8.67
Phosphoric acid	9.12	11.85	8.13
Sulphuric acid	.08	not estimated.	8.40
Chlorine	.35	not estimated.	1.06
Silica	.41	.71	5.86

* Equal to more than 121 pounds of *carbonate of lime or limestone.*

The above table is very instructive as to the peculiar *exhausting* action of the tobacco crop. It will be seen, that not only does it require much more of *all* the essential mineral ingredients of the soil than the grain crops, but that the tobacco is especially a *potash* and *lime* plant, robbing the soil of these materials with very great rapidity, and taking up about as much of one of these substances as of the other.

But when we ascertain the number of years which would be required to reduce the valuable ingredients of the virgin soil, described above, to the quantities found in the "exhausted" soil, by the annual removal of an average tobacco crop, we find, *that if these two soils were originally alike in composition*, which is probable, some other causes have been in operation, during the cultivation of the soil, to aid in its deterioration. For it would have taken nearly seventy years to reduce the *potash*, and about two hundred and seventy-six years to reduce the carbonate of lime, from the quantities contained in the virgin soil to those existing in the "exhausted" soil.

I venture to assert that, in all cases where *hoed crops* have been cultivated, the deterioration of the soil takes place more rapidly than can be accounted for in the vegetable products removed from the land; and especially, when, as is the case with the tobacco, large spaces between the plants are kept clean of vegetable growth during the growing season. Because the atmospheric water filtering through the land, and the active agents, heat, light, and oxygen, are continually decomposing and carrying away more or less of its essential ingredients. If the land is well drained, or on a slope, this action is accelerated; but if its surface is covered with growing vegetables of any kind, these are constantly absorbing the water from the depths of the soil with its dissolved materials, em-

ploying these materials in the formation of their tissues, and finally, when they decay, leaving them to enrich the surface of the ground. Hence land constantly covered with weeds or grass tends to become richer on the surface, whilst similar soil, kept perfectly clear of all vegetable growth, and subject to the atmospheric agencies, must give to the rain water which flows through it, more and more of its valuable soluble ingredients, and undergo great loss of organic matters, &c., by decomposition.

But the reason why the "exhausted" soil failed any longer to produce profitable crops of tobacco, is not because it did not contain *potash, lime, magnesia*, &c., &c., &c. It will be seen, on the contrary, that it still retains enough of all these essential ingredients to constitute it a *pretty good soil.* Doubtless, it would produce good crops of wheat, corn, grass, &c., &c. The tobacco plant requires much nitrogen in its composition, and, *possibly*, enough of this was not furnished in a given time for its wants; it requires a considerable amount of *sulphuric acid* also; but especially, *it requires a large quantity of dissolved materials from the soil within a short space of time*, so that a large amount of the essential ingredients of the soil must be in a *soluble condition*, or, in an *immediately available state*, to enable it to grow with vigor.

In this "exhausted" tobacco soil, the same thing has occurred as frequently takes place with other crops; with clover, for instance; which, after having grown with great vigor for a few years ceases to do well on the same land, which is hence said to be "clover sick;" although the land is far from being exhausted, as is shown by the fact that other crops are produced on it in great abundance.

Clover, like tobacco, withdraws a large amount of *potash, lime*, &c., &c., from the soil. Clover hay, according to Dr. Emmons, gives 5.56 per cent. of ash;* which is of such a composition that a ton of the clover hay takes from the soil in which it has been grown, the following quantities of its essential ingredients:

	Pounds.
Potash	32.153
Soda	18.394
Carbonate of lime	38.378
Magnesia	4.870
Phosphates	25.544
Sulphuric acid	.625
Chlorine	2.288
Silica	1.054

* Natural History of New York, *Agriculture*, part V, page 86.

Clover, like tobacco, or any other quick growing plant, consumes very rapidly the *soluble* or *immediately available* portion of the soil. Clover may be made to exhaust the soil, by cutting and taking it off the land in large hay crops; or it may be made to enrich its surface by grazing it down by hogs or cattle; when the salts are mainly restored to the soil in the excretions of the animals; or by plowing it under as a green manure. At all events, the large roots of this plant are always left to decay in the soil, and tend greatly to enrich the surface and increase its quantity of *soluble* nutritious matters; whilst in the case of the tobacco crop, the whole plant is removed, and the soluble portion of the soil is thus rapidly diminished. Clover, grazed and plowed in, may be advantageously employed, in rotation with the tobacco crop, to sustain the fertility of the soil, and special manures, as lime, plaster of paris, wood ashes, bone dust, or super phosphate of lime, with guano or other animal manures intended to benefit the tobacco crop, might very well be applied to the previous clover crop.

It has been proposed to restore the fertility of tobacco soil by giving it top-dressings of nitre (nitrate of potash;) but this, as might have been expected, has not been found effectual in practice. By studying the composition of the ashes of tobacco, we learn that *lime*, *sulphuric acid*, and other mineral ingredients, are necessary to this plant as well as *potash;* and common sense tells us that an *occasional* supply is not sufficient, but that it is necessary to furnish the nutritive materials to the plant regularly and constantly during the growing season. A compost, rich in *potash*, *lime*, *magnesia*, *phosphates*, *sulphates*, *chlorides*, and *soluble silica*, with *decomposing organic matters*, and *ammonia salts*, or other *nitrogenous compounds*, would, theoretically, supply to the tobacco plant all that is necessary to its growth Such a mixture is contained in good guano, (except that guano is deficient in potash,) and in the urine and fœces of animals, in good barn-yard manure; but it is found that the direct application of such manures is liable to injure the flavor of the tobacco, although they may cause a heavy growth. There is no doubt that this inconvenience may be averted by applying them to the previous crop, as clover, in rotation with the tobacco. Regular irrigation with a weak watery solution, or mixture, of these materials; especially to the young plants; applied to the soil only and not to the plants, according to the Flemish practice, would be the next most effectual mode of supply-

ing them, and would cause a strong growth of the tobacco, as well as maintain the productiveness of the land. But this mode is not likely to be employed in this region at the present time. It is the practice with some tobacco-growers to manure the hill in which the plant is grown by throwing in a handful of *wheat bran*, which by its speedy decomposition furnishes much nutritive mineral matter, in a soluble condition.

The stalks and roots of the tobacco should in all cases be allowed to decay on the land which produced them, or in compost heaps, to furnish it with manure; or, if burnt, the ashes, which contain the valuable mineral elements, should be restored to the soil at the proper season.

On examining *Table VII*, &c., of the tobacco ash analyses, in the appendix, it will be seen that, in the Mason and Bracken county tobacco, generally, there is a deficiency of *chlorine*, as compared with the Havana and Florida tobacco. It might be well for some intelligent cultivators to experiment, by irrigation with weak solutions of chlorides; especially chloride of *ammonium* (common sal ammoniac) and the chlorides of *potassium*, *sodium*, *magnesium*, and *calcium*, (common salt, &c., &c.) Tobacco raised, in this region, directly from the best imported Havana seed, although like its parent plant at first, soon loses its flavor and increases in size. Whether this deterioration is owing to the properties of the soil; to distance from the sea, the air over which always contains marked traces of chlorine, iodine, and bromine, or to other atmospheric or climatic conditions, might perhaps be ascertained by careful and judicious experiment.

Under the head of MASON COUNTY, in this volume, may be found the analyses of other tobacco soils; and in the appendix are recorded the results of the analyses of the ashes of thirty different samples of tobacco from various parts of the State, and from Florida and Cuba, as well as an abstract of some analyses of the ashes of the tobacco leaf and stalk of Massachusetts and Maryland, made by Chas. T. Jackson, M. D.

No. 829—SOIL. *Labeled "Soil from Dr. J. P. Bradford's grape farm near Augusta, Bracken county, Ky. Lower Silurian formation."*

Dried soil of a dirty-buff color.

One thousand grains of the air-dried soil, digested for a month in water, charged with carbonic acid, gave up about *four and a third grains of soluble extract*, dried at 212° F., which had the following

COMPOSITION, VIZ:

Organic and volatile matters	0.700
Alumina and oxides of iron and manganese and phosphates	.280
Carbonate of lime	2.180
Magnesia	.190
Sulphuric acid	.028
Potash	.063
Soda	.011
Silica	.200
Water and loss	.678
	4.330 grains.

The air-dried soil lost 3.675 per cent. of *moisture*, at 400° F., dried at which temperature it has the following

COMPOSITION, VIZ:

Organic and volatile matters	7.412
Alumina	5.990
Oxide of iron	6.975
Carbonate of lime	.871
Magnesia	1.623
Brown oxide of manganese	.260
Phosphoric acid	.289
Sulphuric acid	.033
Potash	1.164
Soda	.058
Sand and insoluble silicates	74.895
Loss	.430
	100.000

A soil remarkably rich in *potash*, well adapted to the culture of the grape. From its very small proportion of sulphuric acid, it is probable its productiveness may be increased by top-dressing of plaster of paris. In the appendix to this Report will be found some analyses which we have made of the Catawba and Herbemont wine of this region; with remarks on the influence of wine culture on the fertility of the soil, &c.

No. 830—SOIL. *Labeled "Clay in which Indian bones are found at Augusta, Bracken county, Ky. Lower Silurian formation."*

The dried sub-soil or under-clay is of a light chocolate color, and was found to contain a few fragments of decayed bones, which were sifted out before proceeding to the analysis.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than three and a half grains of drab colored extract*, dried at 212° F., which had the following

COMPOSITION, VIZ:

Organic and volatile matters	0.200
Alumina and oxides of iron and manganese and phosphates	.250
Carbonate of lime	2.230
Magnesia	.449
Sulphuric acid	.028
Potash	.182
Soda	.068
Silica	.246
Loss	.017
	3.670 grains.

The air-dried soil lost 1.635 per cent. of *moisture*, at 400° F., and thus dried, had the following

COMPOSITION.

Organic and volatile matters	3.497
Alumina	3.360
Oxide of iron	4.095
Carbonate of lime	.495
Magnesia	.593
Brown oxide of manganese	.145
Phosphoric acid	.225
Sulphuric acid	.045
Potash	.319
Soda	.029
Sand and insoluble silicates	86.970
Loss	.227
	100.000

The *phosphates* of the bones do not seem to have been diffused, in any marked manner, through this sub-soil.

No. 831—SOIL. *Labeled "Virgin Soil; James Dunnivan's land. Growth small white oak. Lower Silurian formation, Bracken county, Ky."*

Dried soil of a chocolate-grey color. Some fragments of soft ferruginous sandstone were sifted out of it.

No. 832—SOIL. *Labeled "Soil from an old field, sixty years in cultivation; James Dunnivan's farm, adjoining the preceding," &c., &c.*

Dried soil of a slightly darker color than the preceding; containing some fragments of soft, ferruginous sandstone.

One thousand grains of each of these soils, thoroughly air-dried, were digested, severally, for a month in water charged with carbonic acid. The amount of *soluble materials* extracted is as follows:

	No. 831.	No. 832.
	Virgin soil.	Old field soil.
Organic and volatile matters	0.666	0.283
Alumina and oxides of iron and manganese and phosphates	.150	.047
Carbonate of lime	.530	.680
Magnesia	.166	.096
Sulphuric acid	.037	.022
Potash	.067	.052
Soda	.029	not estimated.
Silica	.197	.081
Loss	.175	.129
Watery extract, dried at 212° F., (grains,)	2.017	1.390

The *composition* of these soils, dried at 400° F., is as follows:

	No. 831.	No. 832.
	Virgin soil.	Old field soil.
Organic and volatile matters	5.931	3.796
Alumina	4.115	3.465
Oxide of iron	3.435	3.210
Carbonate of lime	.170	.220
Magnesia	.836	.869
Brown oxide of manganese	not estimated.	-----------
Phosphoric acid	.254	.227
Sulphuric acid	not estimated.	-----------
Potash	.190	.237
Soda	034	080
Sand and insoluble silicates	84.695	87.070
Loss	.340	.827
Total	100.000	100.000
Moisture, expelled at 400° F.	2.200	2.525

These soils show one of the few exceptions which we have found to the rule, that the long cultivated soil contains less of the essential elements of vegetable composition, than the virgin soil of the same locality. To what cause this apparent anomaly is to be attributed, we do not know, in the absence of any of the sub-soil, which did not come to hand.

BREATHITT COUNTY.

No. 833—SALINE INCRUSTATION, *on Sandstone, called "nitre" where found; mouth of Troublesome Creek. Brought by Messrs. Downie and Lesquereux.*

This was found to be gypsum, or sulphate of lime.

No. 834—COAL. *Labeled "Cannel Coal, Round Bottom, Quicksand Creek; three or four miles from Jackson, Breathitt county, Ky. Whole thickness of the bed thirty-seven inches; the lower twenty-one inches being cannel coal."*

A dull black coal, cleaving in layers, with a satiny lustre on the cross-fracture. No fibrous coal between the layers, and no appearance of pyrites. Does not soil the fingers. Resembles Haddock's cannel coal,* but contains more ash. *Specific gravity* 1.278.

Over the spirit lamp, it gave out much flame; does not soften much nor agglutinate, leaving a dense coke.

PROXIMATE ANALYSIS.

Moisture	0.70	Total volatile matters	44.70
Volatile combustible matters	44.00		
Fixed carbon in the coke	39.90	Dense coke	55.30
Light-grey ashes	15.40		
	100.00		100.00

The percentage of *sulphur* in this coal is 0.452.

COMPOSITION OF THE ASH:

Silica	11.584
Alumina, and oxides of iron and manganese	2.980
Lime	.215
Magnesia	.240
Phosphoric acid	a trace.
Sulphuric acid	.100
Potash and soda and loss	.281
	15.400

To test the oil-producing power of this coal, one thousand grains were submitted to distillation; the heat being gradually raised to a dull red heat, and the products collected in a train of three tubulated receivers, with a bell-glass to collect the gas; and the following results were obtained:

120.30	grains=860 cubic inches of pretty good gas.
273.00	grains of moderately thick crude oil.
30 00	grains of ammoniacal water.
576.70	grains of cellular coke
1000.00	

It does not differ much from Haddock's coal in the production of oil, but yields a greater measure of gas. (See Vol. II, p. 217, of these Reports.)

* See Vol. 1, page 354, of these Reports.

No. 835—COAL. "*Cannel Coal from Mr. South's coal bank, (three feet thick,) near Jackson, Breathitt county, Ky.*" (*Brought from Frankfort by John C. Mason, Esq.*)

Resembles Haddock's cannel coal. A tough, pure, dull-black cannel coal. No fibrous coal between the irregular layers. Presenting an approximation to the bird's-eye structure in some pieces. *Specific gravity* 1.219.

Over the spirit lamp it burns with much flame; swells a little, and leaves a dense coke.

PROXIMATE ANALYSIS.

Moisture	0.30	Total volatile matters	57.00
Volatile combustible matters	56.70		
Fixed carbon in the coke	38.10	Dense coke	43.00
Light-purplish-grey ashes	4.90		
	100.00		100.00

The percentage of *sulphur* was found to be 1.513.

COMPOSITION OF THE ASH.

Silica	1.524
Alumina, and oxides of iron and manganese	1.980
Lime	.417
Magnesia	.199
Phosphoric acid	trace.
Sulphuric acid	.240
Potash	.336
Soda	.142
Loss	.062
	4.900

Submitted to destructive distillation, for the estimation of its oil-pro-producing power, the following results were obtained, viz:

IN THE 1000 GRAINS.

Pretty good gas, and loss	134	grains=675 cubic inches.
Moderately thick crude oil	364	"
Ammoniacal water	36	"
Dense, porous coke	466	"
	1000	

In round numbers, it yields about one third of its weight of *crude oil*, besides a considerable quantity of good illuminating gas. The coke which is left will prove an admirable fuel. No doubt it could be profitably worked for coal oil, of which it yields fully as much as the Breckinridge coal. As this coal does not contain large percentages of *sulphur* and *ash*, the gas from it might be easily purified for illuminating purposes, and the coke could be doubtless employed for foundry purposes.

BRECKINRIDGE COUNTY.

No. 836—SANDSTONE. *Labeled "White Sandstone. Cut of the Breckinridge Coal Company's Railroad, Breckinridge county, Ky."*

A very friable sandstone; easily crushed in the fingers into small clear grains of sand, with a few minute dark-colored specks and small scales of mica. Appears to have no cement to hold the grains of sand together.

Dried at 212° it lost 0.01 per cent of *moisture.* Heated to redness, it lost 0.50 per cent. of water more.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	98.340
Alumina and oxides of iron and manganese	.580
Lime	a trace.
Magnesia	266
Phosphoric acid	a trace.
Sulphuric acid	.042
Potash / Soda	traces.
Water and loss	.772
	100.000

A sandstone pure enough to be employed in the manufacture of white glass. It would be quite refractory in the fire also.

Another specimen was sent to the laboratory labeled "*White Sandstone, Tar Springs, Breckinridge county, base of coal measures,*" which seems to be identical with this.

No. 837—SOIL. *Labeled "Disintegrated Limestone, forty feet below the base of the millstone grit, near the head of Sinking Creek, Breckinridge county, Ky. No plant or tree, nor even moss, grows where this rock furnishes any considerable portion of the soil. Growth, on the top of the sandstone, black jack, and white and red oak; on the face of the limestone, post, and white oak and black jack and a coarse grass."* (*Sent by Mr. S. S. Lyon.*)

This dried soil or powder is of a greenish-grey color.

One thousand grains, air-dried, were digested for a month in water charged with carbonic acid, to which it gave up *more than seven grains of soluble extract, of a whiteish-grey* color, dried at 212° F., the *composition* of which was found to be as follows, viz:

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Organic and volatile matters	0.417
Alumina, and oxides of iron and manganese and phosphates	.064
Carbonate of lime	6.297
Magnesia	.088
Sulphuric acid	not estimated.
Potash	.032
Soda	.028
Silica	.089
	7.015 grains.

The air-dried powder lost 6.25 per cent. of moisture at the temperature of 400° F. Thus dried, its *composition* is as follows, viz:

Organic and volatile matters	1.839
Alumina, and oxides of iron and manganese	2.510
Carbonate of lime	60.050
Carbonate of magnesia	.101
Phosphoric acid	.030
Sulphuric acid	.084
Potash	.217
Soda	.061
Sand and insoluble silicates	34.580
Loss	.528
	100.000

The principal peculiarities in *chemical* composition, presented by the analysis of this disintegrated limestone, are the very large proportion of carbonate of lime and the small amount of phosphoric acid present; with quite a moderate quantity of organic and volatile matters. The carbonated water dissolves a large quantity of the carbonate of lime, causing the soluble extract to appear proportionately great.

This very large amount of carbonate of lime and paucity of phosphoric acid appear to be unfavorable to vegetable life; whilst the peculiar physical condition of this soil contributes to prevent the healthy growth of vegetables upon it. Some remarks by Dr. Owen on a soil of this character, in Vol. I, pages 81 and 82, would seem to apply well in this instance also.

The rock next described is the limestone from whence it is derived.

No. 838—LIMESTONE. *Labeled "Grey Sandy Limestone, from which the above disintegrated limestone was derived, Breckinridge county, Ky."* (*Sent by S. S. Lyon, Esq.*)

A dull, light-grey, granular limestone. Dried at 212° F., it lost 0.10 per cent. of *moisture*, and has the following

COMPOSITION, VIZ:

Carbonate of lime	80.680
Carbonate of magnesia	1.473
Alumina, and oxides of iron and manganese	1.580
Phosphoric acid	a trace.
Sulphuric acid	.166
Potash	.398
Soda	.090
Silex and insoluble silicates	15.580
Loss	.033
	100.000

This limestone contains less phosphoric acid than is usual in rocks of this kind. Had it a larger proportion of carbonate of magnesia, it might be a good hydraulic limestone.

No. 839—SOIL. *Labeled "Virgin Soil, from Mr. Dent's land, two miles north of the base line; one mile west of Sinking Creek, Breckinridge county, Ky. The waste of the limestone* 200 *feet below the base of the millstone grit. Hillside with a capping of the lowest sandstone of the millstone grit; twenty feet of which rest on the top." (Obtained by S. S. Lyon, Esq.)*

Dried soil of a dark umber-brown color.

No. 840—SOIL. *Labeled "Sub-soil of the preceding. Mr. Dent's farm," &c., &c.*

Dried soil of a rich light orange-brown color.

No. 841—SOIL. *Labeled "Virgin Soil, farm of Mr. Davis, on Sugar Camp Creek, Breckinridge county, Ky. Geological position; forty-eight feet above the top of the Tar Spring sandstone. Probably the waste of the second limestone above the base of the millstone grit, and of the sandstone above." (Sent by S. S. Lyon, Esq.)*

Dried soil of a dark-grey color.

No. 842—SOIL. *Labeled "Sub-soil of the preceding. Farm of Mr. Davis," &c.*

Dried soil of a greyish-buff color.

No. 843—SOIL. *Labeled "Soil, from a field fifteen years in cultivation, farm of Mr. Davis, &c. Same Geological position as the two preceding," &c.*

Dried soil of a greyish-buff, or dirty-yellowish color.

No. 844—Soil. *Labeled "Sub-soil of the preceding. Farm of Mr. Davis," &c.*

Dried soil of a rich brownish-buff color, darker than the preceding.

No. 845—Soil. *Labeled "Soil from Mr. Alexander Jones' farm, near the Litchfield and Big Spring road. Geological position: above the lowest sandstone of the millstone grit. Forest growth, black oak, hickory, post and jack oak. Under-growth, hazel, sassafras, and some black gum. Fine tobacco land; but said not to wear well. On the nearly level plateau lying between the heads of Sinking Creek and the small branches of Rough Creek, Breckinridge county, Ky." (Sent by S. S. Lyon, Esq.)*

Dried soil of a light, yellowish, umber color.

No. 846—Soil. *Labeled "Sub-soil of the preceding. Mr. Alexander Jones' farm," &c., &c.*

Dried sub-soil of a greyish-buff color.

One thousand grains of each of these eight soils, thoroughly air-dried, were digested severally for a month, in water charged with carbonic acid. The analyses of the *soluble materials* thus extracted from the soils are given in the following table, viz:

	No. 839. Virgin Soil.	No. 840. Sub-soil.	No. 841. Virgin Soil.	No. 842. Sub-soil.	No. 843. Old field Soil.	No. 844. Sub-soil.	No. 845. Soil.	No. 846. Sub-soil.
Organic & volatile matters	0.753	0.250	0.500	0.263	0.300	0.377	1.100	0.390
Alumina & oxides of iron and manganese and phosphates	.147	.046	.131	.081	.107	.081	.230	.047
Carbonate of lime	5.040	.747	1.197	.263	.563	.347	.797	.130
Magnesia	.211	.055	.133	.101	.101	.096	.160	.086
Sulphuric acid	--------	--------	--------	--------	.028	.028	.062	.018
Potash	.075	.025	.050	.087	.079	.061	.055	.026
Soda	.025	--------	.046	.017	.013	.028	.025	.022
Silica	.200	.131	.156	.264	.230	.131	.180	.097
Loss	.372	.046	.137	.041	.045	--------	.091	.007
Watery extract, dried at 212° F., (grains)	6.823	1.300	2.350	1.117	1.466	1.149	2.700	0.823

The *composition* of these soils, dried at 400° is given in the following table:

	No. 839. Virgin Soil.	No. 840. Sub-soil.	No. 841. Virgin Soil.	No. 842. Sub-soil.	No. 843. Old field. Soil.	No. 844. Sub-soil.	No. 845. Soil.	No. 846. Sub-soil.
Organic & volatile matters	8.411	4.407	5.141	3.513	2.942	3.678	5.136	3.609
Alumina	5.240	6.590	2.315	3.740	3.215	5.165	2.615	5.315
Oxide of iron	4.838	4.460	2.535	3.970	2.335	5.085	2.935	4.010
Carbonate of lime	1.880	.570	.420	.195	.145	.220	.170	.110
Magnesia	.830	.559	.366	.474	.488	.542	.345	.392
Brown oxide of manganese	.345	.120	.120	.195	.095	.070	.195	.170
Phosphoric acid	.130	.152	.160	.094	.085	.095	.095	.095
Sulphuric acid	.076	.016	.059	.033	.028	.033	.055	.041
Potash	.434	.378	.118	.198	.183	.347	.119	.327
Soda	.099	.178	.032	.078	.050	.113	.033	.041
Sand and insoluble silicates	77.495	82.270	88.810	87.120	90.930	83.720	87.645	85.220
Loss	.222	.300	--------	.390	--------	.932	.657	.670
Total	100.000	100.000	100.076	100.000	100.496	100.000	100.000	100.000
Moisture, expelled at 400° F.	4.000	3.000	1.775	1.975	1.425	2.825	2.650	2.350

Soil No. 845 contains too little *lime*, *potash*, and *phosphoric* and *sulphuric acids*, and gives too small a quantity of *soluble matter* to the carbonated water, to prove a very good or durable tobacco soil. The sub-soil contains more potash than the surface soil.

(In the appendix to this Report will be found analyses of the ashes of Indian corn and tobacco from this county.)

BULLITT COUNTY.

No. 847—SANDSTONE. *Labeled "Building Stone. Knob at Bullitt's Lick, Bullitt county, Ky."*

A dull, dirty grey-buff and greenish-grey, rather friable stone. Does not look like a good building material, but may possibly harden by exposure to the weather.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	90.380
Alumina, and oxides of iron and manganese	5.660
Lime	a trace.
Magnesia	.800
Phosphoric acid	.118
Sulphuric acid	.231
Potash	.463
Soda	.142
Water and loss	2.206
	100.000

Dried at 212° F., it lost 0.60 per cent. of *moisture*.

No. 848—Soil. *Labeled "Virgin Soil, from woods west of the Louisville and Nashville railroad, and north of the Gap o' the Knobs, on H. C. Pindell's farm, in Bullitt county, Ky. Sub-soil resting on the Devonian Black Slate formation."* (*Sent by H. C. Pindell, Esq.*)

Dried soil of a light-chocolate color. Some quartzose and ferruginous fragments were sifted out of it.

No. 849—Soil. *Labeled "Soil from a garden, near the 'Gap o' the Knobs,' which has been cleared twelve years, and badly cultivated as a 'truck patch,' or vegetable garden; mostly in corn. On H. C. Pindell's farm, Bullitt county, Ky."*

This garden adjoins the woods from which the preceding specimen of soil was taken. It has a clayey sub-soil, resting on the black slate. The dried soil resembles the preceding, but is a slight shade darker in color. Some quartzose and ferruginous fragments were sifted out of it with the coarse seive.

No. 850—Soil. *Labeled "Sub-soil, from the same hole as the preceding sample. H. C. Pindell's farm," &c., &c.*

Dried sub-soil of a dirty-buff color.

No. 851—Soil. *Labeled "Virgin Soil, from Blue Lick Run bottom, on the Brook's Road from Louisville to Shepardsville. H. C. Pindell's farm, &c."*

Dried soil of a grey-brown color; considerably darker than the two preceding soils. A considerable amount of somewhat rounded fragments of quartzose and ferruginous rock were sifted out of it with the coarse seive.

No. 852—Soil. *Labeled "Virgin Soil, from the top of the hill, north side of Blue Lick Run. H. C. Pindell's farm, &c., Bullitt county, Ky."*

Dried soil of a buff-grey color. Some fragments of quartzose and ferruginous rocks, somewhat rounded, were sifted out of it.

No. 853—Soil. *Labeled "Soil from a field adjoining the woods from which the next preceding sample was taken. The field has been cleared about twenty-five years, and has been cultivated until within the last seven years, when it has been 'turned out.' H. C. Pindell's farm, &c., Bullitt county, Ky."*

Dried soil of a darker color than the preceding. A considerable quan-

tity of fragments of dark ferruginous sandstone was sifted out of it with the coarse seive.

No. 854—Soil. *Labeled "Sub-soil of the preceding; resting on sandstone with nuggets of quartz interspersed through it. H. C. Pindell's farm, &c."*

Dried soil of a light grey-buff color. Some fragments of dark ferruginous sandstone were sifted out of it.

(These soils were collected by H. C. Pindell, Esq.)

One thousand grains of each of these soils, thoroughly air-dried, were digested, severally, for a month, in water charged with carbonic acid. The *soluble materials* extracted from each, by this process, are detailed in the following table, viz:

	No. 848. Virgin Soil.	No. 849. Garden Soil.	No. 850 Sub-soil.	No. 851. Virgin Soil.	No. 852. Virgin Soil.	No. 853. Old field Soil.	No. 854. Sub-soil.
Organic & volatile matters	0.670	0.600	0.185	0.800	Extract accidentally lost after weighing it.	0.337	0.300
Alumina, & oxides of iron & manganese & phosphates	.097	.250	.080	.330		.280	.030
Carbonate of lime	1.130	1.347	.414	2.710		1.613	.097
Magnesia	.400	.222	.222	.620		.166	.100
Sulphuric acid	.033	.098	.034	.022		.028	.041
Potash	.061	.082	.042	.044		.110	048
Soda	.033	.024	.004	.047		.035	.039
Silica	.240	.250	.124	.081		.131	.061
Loss	--------	--------	--------	.716	--------	.130	--------
Watery extract, dried at 212° F., (grains)	2.684	2.803	1.105	5.370	2.725	2.830	0.736

The *composition* of these seven soils is as follows, viz:

	No. 848. Virgin Soil.	No. 849. Garden Soil.	No. 850. Sub-soil.	No. 851. Virgin Soil.	No. 852. Virgin Soil.	No. 853 Old field Soil.	No. 854. Sub-soil.
Organic & volatile matters	5.159	5.143	3.591	7.033	3.674	[illegible]	3.261
Alumina	[illegible]	3.515	6.440	3.840	[illegible]	4.065	6.290
Oxide of iron	3.875	3.195	4.840	5.840	3.290	4.165	[illegible]
Carbonate of lime	[illegible]	.271	.170	1.621	a trace.	.395	trace.
Magnesia	.416	.431	[illegible]	1.643	.451	.828	[illegible]
Brown oxide of manganese	.071	.121	.070	.110	.145	.145	.195
Phosphoric acid	.209	.150	.127	.281	.129	.159	[illegible]
Sulphuric acid	.059	.065	[illegible]	.050	not esti'd	not esti'd	not esti'd
Potash	.256	.217	.276	.211	.125	.092	.477
Soda	.037	[illegible]	.005	.170	.040	.132	.061
Sand and insoluble silicates	86.070	[illegible]	84.110	80.290	88.745	84.395	83.395
Loss	.098	--------	--------	--------	1.011	--------	.248
Total	100.000	100.444	100.226	101.019	100.000	100.193	100.000
Moisture, exp'd at 212° F.	2.075	1.890	[illegible]	2.465	2.725	[illegible]	3.100

These soils, if well drained, and judiciously managed, ought to yield profitable harvests. They are well adapted to the growth of Indian corn, to the culture of the grape, or the peach, &c., &c. The limestone and soft shales, in this neighborhood, some analyses of which follow, might be employed to restore some of the essential ingredients which are removed in the crops or naturally deficient in some of the soils. Soil No. 852 in particular, would no doubt be benefited by liberal top-dressing of slacked lime. The sub-soil No. 854, being quite rich in *potash*, might with great propriety be mixed with the surface soil by means of deep plowing, or the sub-soil plow. Top-dressings of the black slate of this neighborhood, after it has been disintegrated by exposure to the weather, will also tend to increase the proportion of potash in the soil, and aid in the production of herbaceous crops, potatoes, fruits, &c.

No. 855—SHALE. *Labeled "Black (Devonian) Shale, from the Gap o' the Knobs; on H. C. Pindell's farm, Bullitt county, Ky." (Sent by H. C. Pindell, Esq.)*

A dark, umber-colored shale; not adhering to the tongue. Dried at 212° it lost 0.90 per cent. of *moisture*, and has the following

COMPOSITION:

Alumina and oxides of iron and manganese	12.725
Lime	1.458
Magnesia	.367
Phosphoric acid	.246
Sulphuric acid	3.830
Potash	1.271
Soda	.217
Sand and insoluble silicates	69.420
Bituminous matters, water, &c.	12.040
	101.574

In this shale the sulphur, estimated in the above table in the form of sulphuric acid, is mainly combined with iron as sulphuret of iron. The oxidation of these two ingredients accounts, in part, for the excess observed in summing up the analysis. If this shale is easily disintegrated by exposure to the frosts and other atmospheric agents, as is possible, it would be valuable as a top-dressing to the poor, thin lands of this region.

No. 856—MAGNESIAN LIMESTONE. *Labeled "Limestone found under the two preceding soils, Nos. 853 and 854, from H. C. Pindell's farm, Bullitt county, Ky." (Sent by H. C. Pindell, Esq.*

A compact grey limestone; containing many fossil remains; as small encrinital stems, &c., &c. Belonging to the Upper Silurian period.

No. 857—MAGNESIAN LIMESTONE. *Labeled "Limestone from the lime quarry on H. C. Pindell's farm, Bullitt county, Ky," showing the two varieties of limestone taken from the same quarry.*

A portion is of a dull bluish-grey color; the adjoining layer is yellowish-grey; both are fossiliferous and dull, except from the presence of some facets of calc. spar. *Upper Silurian formation.*

No. 858—LIMESTONE. *Labeled "Limestone found in large lumps under the soil, on H. C. Pindell's farm, Bullitt county Ky."*

Encrinital (sub-carboniferous?) limestone; a detached mass.

The *composition* of these three *limestones*, dried at 212° F., is as follows:

	No. 856. Mag'n limestone.	No. 857. Mag'n limestone.	No. 858. Limestone.
Carbonate of lime	50.980	52.880	93.600
Carbonate of magnesia	37.747	37.577	3.314
Alumina, and oxides of iron and manganese	2.700	1.640	.780
Phosphoric acid	a trace.	trace.	trace.
Sulphuric acid	not estimated.	.067	not estimated.
Potash	.463	.270	.297
Soda	.226	.198	.090
Silex and insoluble silicates	6.380	5.980	1.980
Water and loss	1.504	1.388	
	100.000	100.000	100.061

No. 856 would most probably be the best limestone for agricultural purposes, whilst No. 858 will make the whitest lime. A little more silex in these magnesian limestones would make them hydraulic limestones; indeed, as they are, they may yield a lime which may set well under water, if it be mixed with the proper quantity of clean sand.

CAMPBELL COUNTY.

No. 859—IMPURE LIMONITE. *Labeled "Bog Iron Ore, Yeton farm, southern part of Campbell county, Ky."*

Irregular grains, and portions of dark brown limonite, cemented into a porous, friable mass by a dirty brownish-yellow ocherous clay-like substance. Adheres to the tongue. Powder of a dirty-brown color.

Dried at 212° F., it lost 4.90 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	16.600
Alumina	6.920
Carbonate of lime	.980
Carbonate of magnesia	2.396
Brown oxide of manganese	3.480
Phosphoric acid	.950
Sulphuric acid	.269
Potash	.596
Soda	.003
Sand and insoluble silicates	61.280
Combined water	6.500
Loss	.026
	100.000

Too poor and impure to be employed with advantage as an iron ore.

CARTER COUNTY.

No. 860—LIMONITE, INCLUDING CARBONATE OF IRON. *Labeled "Red Kidney Ore, (No. 1*,) from the Star Furnace, Carter county, Ky." (Sent by Messrs. Lampton, Nicholl & Co., the proprietors.)*

An irregular, rounded mass; *exterior layers* of brownish and yellowish limonite, which adheres slightly to the tongue; *interior*, an irregular nucleus of fine-grained carbonate of iron. Some of the exterior portion was taken for analysis. The powder of which is of a brownish-yellow color.

No. 861—LIMONITE. *Labeled "Limestone Ore, (No. 5,) Star Furnace," &c., &c.*

A brownish and yellowish ore. Powder of a yellowish-brown color.

No. 862—LIMONITE. *Labeled "Black Ore, (No. 6,) Star Furnace, &c., &c.*

A dark-colored, friable, porous ore; a nodular mass, with a soft, brownish-yellow, ochreous nucleus. Powder brownish-black.

No. 863—LIMONITE. *Labeled "Yellow Kidney Ore, (No. 7,) Star Furnace," &c., &c.*

An irregular mass, composed of dense, dark-brown, curved, layers; which do not adhere to the tongue; inclosing cavities, generally filled with soft, brownish-yellow, ochreous ore. Powder yellowish-brown.

* The numbers in brackets were attached by Messrs. Lampton, Nicholl & Co.

No. 864—LIMONITE. *Labeled "Limestone Ore, (No. 8,) Star Furnace," &c. &c.*

A dark, rust-red, and dark purplish ore; mottled with lighter colored. Porous; adhering to the tongue. Powder of a red color.

The *composition* of these limonite ores, dried at 212° F., is as follows:

	No. 860. (No 1.) Red kidney	No. 861. (No. 5.) Limestone Ore.	No. 862. (No. 6) Black ore	No. 863. (No. 7.) Yel. kidney Ore.	No. 864. (No. 8.) Limestone Ore.
Oxide of iron	69.740	43.720	39.440	70.872	68.880
Alumina	1.680	1.380	.240	.720	.980
Carbonate of lime	trace.	17.680	1.800	a trace	6.880
Magnesia	1.114	3.022	.836	.999	2.444
Brown oxide of manganese	1.780	1.880	39.677	1.260	.380
Phosphoric acid	.335	2.293	2.101	1.268	1.140
Sulphuric acid	.272	.469	not estim'd	.647	.681
Potash	.270	.374	.270	.386	.231
Soda	trace.	.025	.039	.132	.057
Silex and insoluble silicates	11.680	19.380	1.380	12.980	10.840
Combined water	12.800	9.726	14.300	10.500	6.700
Loss	.329		---------	.216	.787
Total	100.000	100.000	100.123	100.000	100.000
Moisture expelled at 212°	2.200	2.000	3.700	1.740	1.100
Percentage of metallic iron	48.840	30.666	27.620	49.633	48.238

The *purest* of these ores, and that which will yield the toughest iron, is the "*red kidney ore*," No. 860, (No. 1.)

The "black ore," No. 862, (No. 6,) is peculiar in containing as much oxide of manganese as oxide of iron. It owes its dark color to the former oxide. The oxide of manganese is supposed to be useful in ores which are smelted for the manufacture of steel. It unites readily with earthy matters at a high heat and forms quite a fluid "cinder." This black ore contains so much phosphoric acid, however, that it is probable good tough steel metal could not be made from it.

Ore No. 861, (No. 5,) contains a considerable proportion of carbonate of lime, and hence would require very little limestone to flux it; but this also contains so much phosphoric acid, that the iron made from it would probably be brittle or "cold-short;" it would, however, be quite thin when melted, and hence would make sharp castings. This injurious ingredient, which exists in too large proportion in most of the above ores, can be partly removed, in smelting, by the use of an excess of good limestone and of pure *argillaceous* matter, such as pure clay, &c.;

the alumina of which tends to combine with the phosphoric acid, and to carry it off in the cinder. The limestone and clay, or other aluminous material used for the flux, should themselves, of course, be as free as possible from phosphoric acid.

Ore No. 860 should be carefully roasted before smelting, to decompose the interior nucleus of carbonate, which, without roasting, would tend too much to melt and run off in the "cinder."

No. 865—CARBONATE OF IRON. *Labeled "Little Block Ore, (No. 2,) from Star Furnace, Carter county, Ky.," &c.*

Interior of the mass a fine-grained, grey, carbonate of iron. *Exterior,* thin layers of brown limonite, which adheres to the tongue. Powder of a brownish-yellow color; an average portion taken for the analysis.

No. 866—CARBONATE OF IRON. *Labeled "Blue Kidney Ore, (No. 3,) Star Furnace," &c.*

An irregularly rounded, nodular mass of fine-grained, dark lead-colored carbonate of iron; with an infiltrated whitish substance in the fissures, and some specks of yellow pyrites. Powder of a yellowish-grey color.

No. 867—CARBONATE OF IRON. *Labeled "Blue Block Ore, (No. 4,) Star Furnace," &c., &c.*

A block of dark-grey, fine-grained carbonate, about five inches thick; apparently a portion of a layer. Powder of a grey color.

Composition of these three *carbonates of iron,* dried at 212° F.

	No. 865. (No. 2.) Little Block.	No. 866. (No. 3.) Blue Kidney.	No. 867. (No. 4.) Blue Block.
Carbonate of iron	20.190	87.527	60.134
Oxide of iron	51.310	.778	4.775
Alumina	.380	.984	.480
Carbonate of lime	.880	trace.	1.080
Carbonate of magnesia	2.926	1.924	5.105
Carbonate of manganese	1.475	1.324	1.987
Phosphoric acid	.822	.207	.540
Sulphuric acid	.441	.613	.819
Potash	.374	.181	.193
Soda	.010	trace.	.159
Silex and insoluble silicates	11.780	6.680	21.480
Water and loss	9.412	----------	3.248
Total	100.000	100.218	100.000
Moisture, expelled at 212° F.	1.200	0.400	0.54
Percentage of iron	45.688	42.807	32.396

The "blue kidney ore" would probably make the toughest iron. In each of these carbonates, there is a considerable proportion of sulphuric acid; but the use of an excess of limestone in the flux would carry some of it off and prevent the combination of the sulphur with the iron, which would make it "*hot-short*," or brittle when hot.

A very good mode of removing the sulphur from ores which contain yellow pyrites (bi-sulphuret of iron) is, first, carefully to roast them, and then to expose them for some time to the air and rains. The proto-sulphuret of iron, left after the roasting, is thus oxidated into sulphate of iron, (copperas,) which is easily to be washed out of the crumbling ores by water.

No. 868—Impure Limestone. *Labeled "Limestone, (No. 9,) Star Furnace, Carter county, Ky." (Sent by Lampton, Nicholl & Co. Found about forty feet above the yellow kidney ore, used as a flux.*

A dark-brown, almost black, ferruginous limestone; exhibiting some glimmering facets. Powder of a dark-umber color, nearly black. Specific gravity, 2.782. Dried at 212°, it lost 3.00 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.:

Carbonate of lime	50.780
Carbonate of magnesia	3.220
Alumina	.880
Oxide of iron	3.960
Peroxide of manganese	30.260
Phosphoric acid	.950
Sulphuric acid	.475
Potash	.135
Soda	.067
Silex and insoluble silicates	1.880
Water and loss	7.393
	100.000

The very large amount of peroxide of manganese which this limestone contains does not probably injure it for use as a flux in the smelting of iron; especially as the oxide of manganese forms quite fusible compounds when melted with earthy materials. But the considerable proportions of *phosphoric and sulphuric acids* contained in it, render it desirable to substitute a more pure limestone.

No. 869—Pig Iron. *"Pig Iron, made from a mixture of the preceding ores, at Star Furnace, Carter county, Ky." (Sent by Lampton, Nicholl & Co.)*

A rather coarse-grained, specular, grey iron, which yields with some difficulty to the file. Small fragments flatten a little under the hammer,

but easily break to pieces. Exterior of the pig presenting quite a bright appearance, with small shining specular plates. It does not seem to rust very easily. *Specific gravity*, 7.0927.

COMPOSITION.

Iron	90.606	
Graphite	2.100	Total carbon, 3.620
Combined carbon	1.520	
Manganese	1.507	
Silicon	2.181	
Slag	.284	
Aluminum	.301	
Calcium	a trace.	
Magnesium	.303	
Potassium	.073	
Sodium	a trace.	
Phosphorus	1.404	
Sulphur	.135	
	100.414	

It contains too much phosphorus to be very tough iron. The quality of the iron at this furnace might be improved, as to *strength* particularly, by selecting the best ores—those which contain the least phosphorus and sulphur—and by using a purer limestone for the flux.

No. 870—COAL. *Labeled "Bituminous Coal, found from thirty-five to forty feet above the yellow kidney ore, in bed varying from four to six feet thick. Star Furnace, Carter county, Ky."* (*Sent by Lampton, Nicholl & Co.*)

A shining, pitch-black coal, with very little fibrous coal between the layers. Exhibiting some reed-leaf like impressions. Scarcely soiling the hands. Over the spirit lamp it decrepitated, swelled up considerably, but the fragments did not agglutinate. Specific gravity, 1.266.

PROXIMATE ANALYSIS.

Moisture	7.70	Total volatile matters	44.20
Volatile combustible matters	36.50		
Fixed carbon in the coke	53.80	Dense coke	55.80
Grey-buff ashes	2.00		
	100.00		100.00

The percentage of *sulphur* in this coal is 1.267.

COMPOSITION OF THE ASH.

Silica	0.900
Alumina, and oxides of iron and manganese	.320
Lime	.120
Magnesia	.340
Potash	.100
Soda	.120
Loss	.100
	2.000

This is quite a pure coal, retaining, however, more than the usual proportion of *moisture,* to which no doubt is owing its decrepitation when suddenly heated.

No. 871—COAL. *Labeled "Cannel Coal, twenty-one inches, with a clay parting of four inches, over which four to six inches. Stinson Bank, Carter county, Ky." Obtained by Dr. Owen.*

A dull-black, very tough coal; cleaving in very thin layers, which have impressions of quite small narrow reed-like leaves in fibrous coal. Specific gravity, 1.200.

Over the spirit lamp it did not swell nor alter much in form.

PROXIMATE ANALYSIS.

Moisture	0.60	Total volatile matters	66.90
Volatile combustible matters	66.30		
Fixed carbon in the coke	28.30	Dense coke	33.10
Tawny yellowish ashes	4.80		
	100.00		100.00

The percentage of sulphur in this coal is 1.320.

COMPOSITION OF THE ASH.

Silica	1.884
Alumina, and oxides of iron and manganese and phosphates	1.680
Lime	.271
Magnesia	.633
Sulphuric acid	.304
Potash	.127
Soda	.170
	5.067

Submitted to destructive distillation, in an iron retort, at a heat slowly raised to dull redness, the following results were obtained from one thousand grains of this coal, viz:

Crude oil, thin	436 grains.
Ammoniacal water	40 grains.
Coke	384 grains.
Combustible gases and loss	140 grains=to 670 cubic inches.
	1000

It will be seen, by reference to Vol. II, p. 217, of these Reports, that this yield of *crude oil* exceeds that obtained from any other Kentucky cannel coal hitherto submitted to experiment, including the celebrated Breckinridge coal. This coal is also superior to that because of its small percentage of sulphur and of ashes. For these reasons the coke would be a much better fuel than that from the Breckinridge coal, and the gas might be easily purified for illuminating purposes. If the process were

carried on in a city, where it might be advantageously employed: for although it does not give as much light as gas made from the Pittsburg coal, distilled at a higher temperature; yet, sold at a lower price, it would doubtless find a ready sale.

The yield of crude oil in the experiment above described is quite remarkable; equal to (872 lbs.) eight hundred and seventy-two pounds, or nearly one hundred and ten gallons to the ton, (2000 lbs.) Whether the specimen tried is richer than the average of the bed can only be ascertained by trial. But the probability is that this bed of coal is peculiarly fitted for the manufacture of coal oils. See further on for the examination of another specimen of cannel coal from Stinson creek.

No. 872—COAL. *Labeled "Sample of Coal from the upper eighteen inches of openings on Carter's Hill; (property of Robert Carter, of Grayson;) half a mile north of Grayson Court-House, Carter county, Ky."* (*Obtained by Joseph Lesley, jr., Esq.*)

A dull black, very friable, coal; separating easily into thin layers. Over the spirit lamp it does not change form nor give much flame; leaving a soft friable coke, easily incinerated.

PROXIMATE ANALYSIS.

Moisture	1.26	Total volatile matters	40.90
Volatile combustible matters	39.64		
Fixed carbon in the coke	49.40	Pulverulent coke	59.10
Buff-grey ashes	9.70		
	100.00		100.00

The percentage of *sulphur* is 0.694.

The ash contains large proportions of alumina, oxide of iron, carbonate of lime, and magnesia, so that they are probably easily to be melted into clinker.

No. 873—COAL. *Labeled "Sample of the under eighteen inches of opening on Carter's Hill, half a mile north of Grayson Court-House, Carter county, Ky."* (*Obtained by Joseph Lesley, jr., Esq.*)

A somewhat dull, pitch-black, coal; some portions deep shining black; not much fibrous coal between the layers. Some thin incrustations of pyrites in the cracks and joints.

Over the spirit lamp, it softened somewhat, and agglutinated into a moderately dense coke. Specific gravity, 1.298.

PROXIMATE ANALYSIS.

Moisture	4.40	Total volatile matters	39.40
Voluble combustible matters	35.00		
Fixed carbon in the coke	52.70	Moderately dense coke	60.60
Purplish-grey ashes	7.90		
	100.00		100.00

The percentage of *sulphur* in this sample is 3.261.

COMPOSITION OF THE ASHES.

Silica	3.584
Aluminia and oxides of iron and manganese and phosphates	3.680
Lime	a trace.
Magnesia	.279
Sulphuric acid	.166
Potash	.251
Soda	.107
	8.067

No. 874—Coal. *Labled "Bituminous Coal, from the upper part, (above the slate parting,) of the bed on Tar Kiln branch of Stinson's creek; and on the Mount Savage property, Carter county, Ky."* (*Obtained by Joseph Lesley, jr., Esq.*)

A shining, deep pitch-black, rather brittle coal. Much soft fibrous coal between the layers. Over the spirit-lamp it softens and agglutinates, and swells up into a spongy coke. Specific gravity, 1.299.

PROXIMATE ANALYSIS.

Moisture	[illegible]	Total volatile matters	40.20
Volatile combustible matters	35.94		
Fixed carbon in the coke	53.30	Moderately densè coke	59.80
Purplish-grey ashes	6.50		
	100.00		100.00

The percentage of *sulphur* in this coal, is 2.339.

COMPOSITION OF THE ASH.

Silica	1.644
Alumina, and oxides of iron and manganese and phosphates	4.080
Lime	trace.
Magnesia	.133
Sulphuric acid	.013
Potash	.011
Soda	.012
Carbonic acid and loss	.607
	6.500

No. 875—Coal. *Labeled "Cannel Coal from the under part of the bed on Tar Kiln branch of Stinson's Creek, on the Mount Savage property, Carter county, Ky. This coal is used in Ashlaud for making oil."* (*Obtained by Joseph Lesley, jr., Esq.*)

A dull black, very tough coal, breaking with difficulty and irregularly,

into thin layers; the fragments generally with sharp edges. No fibrous coal between the layers. The cross-fracture is somewhat conchoidal, with a satiny lustre.

Over the spirit lamp, it gives much smoky flame; does not soften, nor swell much; leaving a friable quite combustible coke. Specific gravity 1.145.

PROXIMATE ANALYSIS.

Moisture	0.90	Total volatile matters	65.06
Volatile combustible matters	64.16		
Fixed carbon in the coke	27.04	Friable coke	34.94
Purplish-grey ashes	7.90		
	100.00		100.00

The percentage of *sulphur* in this coal is 2.843.

COMPOSITION OF THE ASH.

Silica	2.784
Alumina, and oxides of iron and manganese	4.240
Lime	.550
Magnesia	.299
Sulphur, phosphoric acid, and alkalies	not estimated
	7.873

One thousand grains, submitted to destructive distillation in an iron retort, at a heat gradually raised to dull redness, gave of

Thin crude oil	411 grains.	
Ammoniacal water	40 "	
Porous coke	367 "	
Combustible gases and loss	182 "	=675 cubic inches.
	1000	

This yield of crude oil is second only to that from a similar specimen of cannel coal from Stinson's bank, (described above,) amongst all the Kentucky coals which have been examined. It is equal to eight hundred and twenty-two pounds, (822 lbs.) or about one hundred gallons of crude oil to the ton (of two thousand pounds) of the coal. It is doubtful whether the Boghead coal of Scotland gives so large a product of oil.

CLARKE COUNTY.

No. 876—Magnesian Limestone. *Labeled "Building Stone; quarry mouth of Lower Howard's Creek, Clarke county, Ky. Lower Silurian formation."*

A dull, light-buff, fine-granular rock; resembling that from Grimes' quarry in Fayette county. Specific gravity 2.735.

Dried, in powder, at 212° F., it lost only 0.30 per cent. of *moisture.*

COMPOSITION DRIED AT 212° F.

Carbonate of lime	60.640=34.028 lime.
Carbonate of magnesia	32.500=15.040 magnesia.
Alumina, and oxides of iron and manganese	.580
Phosphoric acid	.207
Sulphuric acid	.124
Potash	.374
Soda	.250
Silex and insoluble silicates	3.520
Moisture and loss	1.805
	100.000

This is doubtless a good and durable building stone; resembling that employed in the construction of the Clay Monument at Lexington.

No. 877—LIMESTONE. *Labeled "Rock from which the soil is derived, collected on Judge Simpson's farm, near Winchester, Clarke county, Ky. Lower Silurian formation."*

A coarse-granular limestone; very much weathered and disintegrated, and very full of fossil shells. Exterior surface coated with dirty-grey-buff soil.

Dried at 212° F. it lost 0.20 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	85.560=48.017 lime.
Carbonate of magnesia	3.567
Alumina, and oxides of iron and manganese	3.280
Phosphoric acid	.118
Sulphuric acid	.474
Potash	.422
Soda	.462
Silex and insoluble silicates	5.920
Loss	.187
	100.000

A limestone remarkably rich in the alkalies and sulphuric acid, and containing a considerable proportion of phosphoric acid.

No. 878—SOIL. *Labeled "Virgin Soil, from woods pasture, on Judge Simpson's farm, near Winchester, Clarke county, Ky. Primitive growth, black walnut, locust, mulberry, blue ash, &c. Lower Silurian formation." (Obtained by Dr. Owen.)*

Dried soil of a light-greyish-brown color.

No. 879—SOIL. *Labeled "Soil from an old field, thirty years or more in cultivation, adjoining the preceding, Judge Simpson's farm," &c.*

Dried soil of a light grey-brown color; lighter colored than the preceding.

No. 880—SOIL. *Labeled "Sub-soil of the same old field. Judge Simpson's farm," &c., &c.*

Dried soil a little darker and more yellowish than the preceding.

No. 881—SOIL. *Labeled "Virgin Soil, from Wm. R. Duncan's farm, Clarke county, Ky. (From a lower situation than the old field from which the next preceding soil was taken; and more of a meadow soil.) Forest growth, sugar-tree, black locust, white and blue ash. Blue limestone formation." (Collected by Dr. Owen.)*

Dried soil of a dark, dirty, grey-buff color.

No. 882—SOIL. *Labeled "Soil from an old field, upwards of forty years in cultivation, on Wm. R. Duncan's farm," &c., &c.*

Dried soil slightly darker colored than the preceding.

No. 883—SOIL. *Labeled "Sub-soil, from the same old field, Wm. R. Duncan's farm," &c.*

Dried soil slightly darker than the preceding.

One thousands grains of each of these soils, thoroughly air-dried, were digested for a month, severally, in water charged with carbonic acid; the *soluble matters* extracted are detailed in the following table, viz:

	No. 878. Virgin Soil.	No. 879. Old field.	No. 880. Sub-soil.	No. 881. Virgin Soil.	No. 882. Old field.	No. 883. Sub-soil.
Organic and volatile matters	1.717	0.533	0.500	0.705	0.467	0.833
Alumina, and oxides of iron and manganese and phosphates	.280	.114	.080	.167	.181	.114
Carbonate of lime	2.887	2.231	1.447	1.347	.781	.814
Magnesia	.149	.092	.067	.069	.110	.067
Sulphuric acid	.041	.032	.030	.033	.045	.041
Potash	.094	.087	.061	.035	.054	.058
Soda	.008	.004	.030	.009	.024	.013
Silica	.147	.264	.181	.147	.180	.254
Loss	.310	.243	.004	.101	.075	--------
Watery extract, dried at 212° F., (grains)	5.633	3.600	2.400	2.633	1.917	2.194

The sub-soil No. 883, gives up more *soluble matter* to the carbonated water than the surface soil above it, which is quite an unusual circumstance, and may, most probably, be attributed to the fact that it contains as much organic matters and lime, and more magnesia, potash, sulphates

and phosphates, than that. (See following table.) Sub-soil plowing would, therefore, be *immediately* beneficial to this old field.

The composition of these soils, dried at 400° F., is as follows:

	No. 878. Virgin Soil.	No. 879. Old field.	No. 880. Sub-soil.	No. 881. Virgin Soil.	No. 882. Old field.	No. 883. Sub-soil.
Organic and volatile matters	9.028	6.379	5.797	7.764	5.985	5.923
Alumina	6.565	4.240	7.165	6.790	6.240	6.290
Oxide of iron	5.600	4.960	5.460	5.860	5.785	5.885
Carbonate of lime	.545	.695	.320	.345	.195	.195
Magnesia	.687	.563	.859	.883	.719	1.133
Brown oxide of manganese	.545	.320	.370	.330	.320	.895
Phosphoric acid	.366	.211	.228	.306	.245	.296
Sulphuric acid	.084	.084	.050	.092	.067	.076
Potash	.475	.296	.583	.589	.396	.507
Soda	.124	.056	.053	.005	.034	.065
Sand and insoluble silicates	76.070	81.920	79.620	76.820	79.945	79.970
Loss	--------	.276	--------	.216	.069	--------
Total	100.089	100.000	100.505	100.000	100.000	100.735
Moisture, expelled at 400°	4.750	3.125	3.400	4.050	3.350	3.350

These are rich soils, like the blue limestone soils generally. The sub-soil is quite rich in potash, like much of the sub-soil and under-clays on this formation. As usual, the soils of the old fields show evident signs of deterioration, in the reduction of the proportions of the essential elements of vegetable nutrition. Soil No. 881 contains less of its elements in an immediately soluble condition than soil No. 878; probably because it has less *organic matters*, and less lime than that.

No. 884—SOIL. *Labeled "Virgin Soil, from Woodland, on the farm of Mr. John Goff, near Kiddville, Clarke county, Ky. Indian old fields. Forest growth, oak and hickory. Devonian Sandstone formation." (Obtained by Messrs. Downie and Lesquereux.)*

The dried soil is of a light, greyish umber color. A considerable quantity of iron gravel, or shot iron ore, was sifted out with the coarse seive.

No. 885—SOIL. *Labeled "Soil from an old field, adjoining the preceding, fifteen years in cultivation; taken three inches below the surface; farm of Mr. John Goff," &c., &c.*

Dried soil of a dark umber color, contains iron gravel.

No. 886—Soil. *Labeled "Sub-soil, from a corn-field adjoining the two preceding, taken nine inches below the surface. Mr. Jno. Goff's farm," &c., &c.*

Dried soil darker colored than the preceding, of a dark umber color, verging to soot colored. More than a third of its weight of iron gravel was removed from it, with the coarse seive, before analysis.

One thousand grains of each of these soils were digested, severally, for a month, in water charged with carbonic acid; the analyses of the *soluble materials* extracted are given in the following table, viz:

	No. 884. Virgin soil.	No. 885. Old field.	No. 886. Sub-soil.
Organic and volatile matters	1.327	1.190	0.750
Alumina, and oxides of iron and manganese and phosphates	.853	1.453	.330
Carbonate of lime	.987	2.296	1.113
Magnesia	.172	.233	.259
Sulphuric acid	.037	.056	.045
Potash	.093	.026	.015
Soda	.028	.049	.067
Silica	.198	.198	.314
Loss	.082	.289	----------
Watery extract, dried at 212° F., (grains)	3.777	5.790	1.893

The soil of the old field gives up a larger quantity of soluble matters than the virgin soil, principally because it contains more carbonate of lime and sulphuric acid.

The *composition* of these soils, dried at 400° F., is as follows, viz:

	No. 884. Virgin soil.	No. 885. Old field.	No. 886. Sub-soil.
Organic and volatile matters	7.195	6.842	9.263
Alumina	5.615	5.690	6.815
Oxide of iron	6.635	9.535	12.310
Carbonate of lime	.120	.820	.345
Magnesia	.948	.772	.855
Brown oxide of manganese	.220	.145	.170
Phosphoric acid	.346	.384	.217
Sulphuric acid	.050	.127	.067
Potash	.580	.265	.463
Soda	.409	.122	.088
Sand and insoluble silicates	78.470	75.170	69.220
Loss	----------	.128	.187
Total	100.588	100.000	100.000
Moisture, expelled at 400° F.	3.750	5.000	5.275

These soils have the composition of very rich soils, and if they are well drained, and otherwise under favorable physical circumstances, they ought to produce large crops. The proportions of carbonate of lime, and of sulphuric and phosphoric acids, in the virgin soil are below those contained in the soil of the old field, and it gives up much less soluble matter to carbonated water than that; it also exhibits a larger proportion of sand and insoluble silicates, but a much greater quantity of potash. Top-dressings of lime and of plaster of paris would be advantageous to the virgin soil for most crops. The proportions of oxide of iron in soils Nos. 885 and 866 are unusually large, and contribute to give them their dark color. The organic matter contained in the sub-soil is also unusually large in quantity.

No. 887—LIMONITE. *Labeled "Iron gravel from the sub-soil of Indian old fields, Clarke county, Ky."* (*See the preceding soil.*)

COMPOSITION, DRIED AT 212° F.

Oxides of iron and manganese and alumina	66.060
Carbonate of lime	.084
Magnesia	.266
Phosphoric acid	1.015
Sulphuric acid	.132
Potash	.349
Soda	.181
Silex and insoluble silicates	19.040
Water, organic matter, and loss	12.873
	100.000

It contains a considerable proportion of phosphoric acid, but this, being combined with the per oxide of iron, or alumina, is not easily taken up by the atmospheric water.

No. 888—LIMESTONE. *Labeled "Hydraulic Limestone; base of the Black Slate, Clarke county, Ky. Found also in Madison, Bath, Powell, Estill, &c."* (*Sent by S. S. Lyon, Esq.*)

The dense calcareous portion of the grey-black slate.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	40.280
Carbonate of magnesia	15.903
Alumina, and oxides of iron and manganese and phosphates	9.460
Sulphuric acid	1.025
Potash	.436
Soda	.164
Silex and insoluble silicates	23.180
Bituminous matter, water, and loss	9.552
	100.000

It is probable that with proper management this limestone will make a good hydraulic cement.

No. 889—LIMESTONE. *Labeled "Sandstone? with oil, (bitumen,) base of the Marcellus shale, Oil Springs, Clarke county, Ky." (Obtained by Messrs. Downie and Lesquereux.)*

A dark-grey limestone, with its calcareous-spar-lined cavities impregnated with fluid bitumen. Weathered surfaces of a dull buff color.

Dried at 212°, it lost 0.01 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	56.760
Carbonate of magnesia	21.302
Alumina, and oxides of iron and manganese	11.260
Phosphoric acid	.438
Sulphuric acid	.372
Potash	.193
Soda	.103
Silex and insoluble silicates	2.480
Bituminous matters and loss	7.092
	100.000

CRITTENDEN COUNTY.

No. 890—CARBONATE OF IRON. *Labeled "Iron Ore, Sneed's mines on Tradewater River, Crittenden county, Ky."*

A dense, dark-reddish-brown ore; not adhering to the tongue. A whitish incrustation in the fissures. Specific gravity 3.1066. Powder brownish-drab color.

Dried at 212° F., it lost 0.40 per cent. of moisture.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	64.239	32.843 per cent. of iron.
Oxide of iron	2.723	
Alumina	1.120	
Carbonate of lime	.680	
Carbonate of magnesia	2.118	
Carbonate of manganese	.662	
Phosphoric acid	.758	
Sulphuric acid	.372	
Potash	.379	
Soda	trace.	
Sand and insoluble silicates	26.480	
Water and loss	.469	
	100.000	

Sufficiently rich to be smelted, but containing rather too much phosphorus and sulphur to make a very *tough* malleable iron.

ORES, &c., FROM CRITTENDEN FURNACE.

No. 891—LIMONITE. *Labeled "Pipe Ore. Crittenden Furnace, Crittenden county, Ky, (G. D. Cobb & Co.") (Obtained by John Bartlett, Esq.)*

A dark brown limonite ore; some of it exhibiting an irregular tuber-

culated, columnar, structure. Exterior covered with reddish and yellowish ochreous ore. Powder of a rich brownish-yellow color.

No. 892—LIMONITE. *Labeled "Pot Ore" Crittenden furnace," &c.*

A layer of dense, dark-colored limonite ore, (nearly of the color of blacksmith's anvil scales,) forming a geode; the interior surface of which exhibits iridescence, and is studded with small tubercles. The cavity contained, on what appeared to have been the lower surface, a thin layer of pink-grey silicious matter easily reduced to powder. Exterior of the geode of an umber-brown color. Powder of a reddish-brown color.

No. 893—LIMONITE. *A portion of the exterior oxidated layer of the "Block Ore, (No. 896, described below.) Crittenden furnace," &c.*

A dense, compact limonite; not adhering to the tongue. Powder of a rich brownish-yellow color. Specific gravity 3.5195.

No. 894—LIMONITE. *Labeled "Brown Ore." Crittenden Furnace, &c., &c. "A large solid specimen of unique form."*

A dense, dark-brown limonite, coated with yellow ochreous ore, in the shape of a knotty branching stem. Not adhering to the tongue. The fractured surface glimmers, in some places, from the presence of small scales of mica. Powder of a rich brownish-yellow color.

No. 895—LIMONITE. *Labeled "Honey-comb Ore, Crittenden Furnace."*

A dark-brown, porous limonite ore; incrusted with light red ochreous ore.

The *composition* of these five limonite ores, from Crittenden furnace, dried at 212° F., is as follows:

	No. 891. Pipe Ore.	No. 892. Pot Ore.	No. 893. Ext'r layer. Black Ore.	No. 894. Brown Ore.	No 895. Honey-comb Ore.
Oxide of iron	78.140	80.940	81.000	72.140	81.340
Alumina	.580	.580	.580	.480	1.340
Carbonate of lime	a trace	trace.	trace.	trace.	trace.
Magnesia	.680	.474	.796	.308	.503
Brown ox. of manganese	.580	.380	.180	.880	.360
Phosphoric acid	.502	.502	.886	.438	1.204
Sulphuric acid	.133	.201	trace.	.166	.132
Potash	.328	.328	.320	.417	.181
Soda	.014	.202	.150	.180	.064
Silex & insol'ble silicates	7.780	11.520	5.180	16.980	4.380
Combined water	11.000	5.300	10.900	10.200	11.140
Loss	.263	----------	.008	----------	----------
Total	100.000	100.427	100.000	102.189	100.644
Moist., exp'd at 212° F.	0.800	1.100	0.800	0.200	1.000
Percentage of iron	54.722	56.684	56.725	50.521	56.954

Ore No. 895, honey-comb ore, contains more phosphoric acid than any of the Crittenden furnace ores; and the "brown ore," No. 894, contains the least of this injurious ingredient, and would probably yield the toughest iron. These ores are all quite rich in iron, and contain but little alumina, and hardly a trace of lime. The quality of the iron produced would, no doubt, be improved by the use of a large proportion of pure limestone with the addition of pure clay or some other aluminous material, for the flux. This would carry off some of the phosphoric acid in the "cinder."

No. 896.—CARBONATE OF IRON. *Labled "Block Ore. Crittenden furnace, Crittenden county, Ky."*

A fine-grained, dark-grey carbonate, not adhering to the tongue; with a thin layer of yellowish-brown limonite on the exterior, (the composition of which is given above, (No. 894.) (A portion of the grey interior taken for the present analysis.) Powder of a yellowish-grey color. Specific gravity 3.353. Dried at 212° it lost 0.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	64.191	32.943 per cent. of iron.
Oxide of iron	2.948	
Alumina	.480	
Carbonate of lime	2.124	
Carbonate of magnesia	13.205	
Carbonate of manganese	1.324	
Phosphoric acid	.822	
Sulphuric acid	.201	
Potash	.704	
Soda	.260	
Silex and insoluble silicates	12.980	
Loss	.761	
	100.000	

This analysis and that of the exterior layer of this ore, (No. 894,) illustrate the manner in which the ores of the *carbonate of the protoxide of iron* become gradually converted, by exposure to the atmospheric agencies, into ores of *hydrated peroxide of iron*, or *limonites.* The oxygen of the air gradually displaces the carbonic acid in the ore, and this latter acid, with the water which frequently washes the ore, gradually remove the carbonates of lime, magnesia, and manganese, and a portion of the alkalies and sulphuric acid, leaving, however, most of the phosphoric acid in insoluble combination with the peroxide of iron.

No. 897—LIMESTONE. *Labeled "Blue Limestone, used as a flux at Crittenden Furnace, Crittenden county, Ky. Found near the Furnace. Very good." (Obtained by Mr. Bartlett.)*

A light slate-colored, fine-grained limestone, giving a bituminous odor when hammered, and presenting a black thin coating on some of the layers, probably bituminous. Dull in appearance generally, but presenting a few facets of calc. spar. Not adhering to the tongue.

No. 898—LIMESTONE. *Labeled "Grey Limestone, used as a flux at Crittenden Furnace, &c. Found near the Furnace Inferior to the blue."*

A light, reddish-grey, dull, fine-grained limestone; adhering slightly to the tongue.

COMPOSITION OF THESE TWO LIMESTONES, DRIED AT 212° F.

	No. 897. Blue limestone.	No. 898. Grey limestone.
Carbonate of lime	52.880	55.280
Carbonate of magnesia	25.858	29.246
Alumina, and oxides of iron and manganese	1.460	1.323
Phosphoric acid	.098	.117
Sulphuric acid	.003	a trace.
Potash	.394	.344
Soda	.255	.056
Silex and insoluble silicates	18.880	14.280
Loss	.172	
	100.000	100.646
Specific gravity	2.719	2.723
Moisture lost at 212° F.	0.10	none.
Percentage of lime	29.675	31.020

These are both magnesian limestones; resembling each other a good deal in composition. No good reason can be given, from the analyses, why the one is preferred to the other; except that the *blue* contains a little less of phosphoric acid and of magnesia, and a little more of the alkalies and silica than the grey. The former may therefore be a little more fusible; but the latter contains a larger percentage of lime. These limestones would, no doubt, make good hydraulic cement.

No. 899.—SANDSTONE. *Labeled "Hearthstone, (best,) found two miles from Crittenden Furnace, Crittenden county, Ky."*

A light-salmon-colored sandstone, so friable as to be easily crushed in the fingers. Under the lens the clear quartz grains do not appear to be

united by any cement. Some small black specks and a little oxide of iron give the color to it.

No. 900.—SANDSTONE. *Labeled "Hearthstone, (second quality,) same locality as the last, Crittenden Furnace, &c., &c."*

Lighter colored, finer grained, and apparently more pure than the preceding, which it resembles; nearly white.

COMPOSITION, &C., DRIED AT 212°.

	No. 899. Best.	No. 900. Second quality.
Sand and insoluble silicates	99.080	98.680
Alumina and oxides of iron and manganese	.080	.380
Lime	trace.	trace.
Magnesia	.360	.400
Phosphoric acid	trace.	trace.
Sulphuric acid	.063	trace.
Potash	.386	.464
Soda	.121	.058
Water expelled at a red heat	.300	.500
	100.390	100.482

Neither of them lost an appreciable quantity of *moisture* at 212° F. Experience, with the intense heat of the iron furnace, have demonstrated which is *really* the purest sandstone, and, consequently, which is the least fusible.

Four specimens of the pig iron of Crittenden furnace were selected for analysis by Mr. John Bartlett, described as follows:

No. 901.—PIG IRON. *Labeled "Grey iron from mixed ores," Crittenden Furnace, Crittenden county, Ky.*

A moderately fine-grained, grey iron. Small fragments are easily broken under the hammer. Yields with difficulty to the file.

No. 902—PIG IRON. *Labeled "Lively Grey Iron, (No. 1, forge iron,) Crittenden Furnace, &c."*

Rather finer-grained than the preceding. Small fragments flatten under the hammer, but soon break to pieces. Yields easily to the file.

No. 903—PIG IRON. *Labeled "Grey Iron from 'Pipe Ore' alone, Crittenden Furnace, &c."*

Coarser grained and somewhat lighter colored than the two preceding; presenting more distinct brilliant, (specular,) scales. More tough than

the preceding; small fragments extend a little under the hammer, but soon break. Yields more easily to the file.

No. 904—Pig Iron. *Labeled "White Iron, Crittenden Furnace, &c."*

Hard; yields with difficulty to the file; somewhat tough; small fragments flatten under the hammer. White; fracture presenting a confused bladed crystalline appearance.

COMPOSITION OF THE FOUR PIG IRONS.

	No. 901.	No. 902.	No. 903.	No. 904.
Iron	90.733	91.094	91.111	93.879
Graphite	1.884	2.024	2.224	.384
Combined carbon	1.716	.340	.420	4.500
Manganese	.129	.633	.417	.344
Silicon	3.490	3.777	3.508	.623
Slag	.664	.724	.984	.084
Aluminum	.084	.202	.202	.202
Calcium	trace.	trace.	trace.	trace.
Magnesium	.271	.414	.417	.451
Potassium	.102	.080	.054	.080
Sodium	.065	.097	.077	.097
Phosphorus	.864	.443	.320	.451
Sulphur	.127	.052	.052	.127
	100.129	99.880	99.786	101.222
Total carbon	3.600	2.364	2.642	4.884
Specific gravity	6.9833	6.9902	6.6033	7.3988

The "white iron" is purer than any of the other samples. As is well known, it owes its whiteness and hardness to the carbon being in a *chemically combined* state; whilst in the soft *grey iron* the carbon is in a separated state, and simply *mixed* in the iron, in the form of fine scales of *graphite* or plumbago.

There is rather more *phosphorus* in most of these specimens than is desirable, and the *silicon* is also in considerable proportion. Both tending to make the iron brittle or "cold short." It would no doubt improve the toughness of the metal to use a larger proportion of *good* limestone in the flux; say one half more than has generally been used at this furnace; so that *bi-silicates*, instead of *tri-silicates*, would be formed, with the earthy matters, in the cinder.

Four characteristic specimens of "cinder" or furnace slag, were collected for analysis, at this furnace, by Mr. John Bartlett. The details of the examination of which are as follows:

No. 905—IRON FURNACE SLAG. *Labeled "Cinder from the 'white iron,' Crittenden Furnace, Crittenden county, Ky."*

A vitrified greyish-bottle-green, tending to olive green, slag; transparent on the edges; containing bubbles. Easily fusing, before the blow-pipe, into a blebby globule.

No. 906—IRON FURNACE SLAG. *Labeled "Cinder from the grey iron from mixed ores, Crittenden Furnace, &c."*

A dark, smokey-blue dense glass; with striæ of darker and lighter; transparent in thin fragments; contains no bubbles. In oxidating flame of blow-pipe easily melts into a blebby globule.

No. 907—IRON FURNACE SLAG. *Labeled "Cinder from the lively grey, forge iron, Crittenden Furnace, &c."*

An opake grey-blue, vescicular slag; translucent on the edges and containing brilliant plates of graphite and involved charcoal. In oxidating flame of the blow-pipe, very easily fusible into a clear, bottle-green globule.

No. 908—IRON FURNACE SLAG. *Labeled " Cinder from the 'Pipe Ore' alone, Crittenden Furnace, &c."*

A dense purplish, smoky-colored slag; transparent in thin fragments; containing no bubbles. In the oxydating flame of the blow-pipe, melts easily with much intumescence, into a whitish, blebby globule.

COMPOSITION OF THESE FOUR SLAGS.

	No. 905. Slag from white iron.	No. 906. From mixed ores.	No. 907. From lively grey iron.	No. 908. From pipe ore alone.
Silica	59.580	61.980	64.880	65.520
Alumina	7.980	9.080	7.480	8.280
Lime	23.164	24.623	15.847	22.155
Magnesia	1.358	1.538	1.287	1.645
Protoxide of iron	4.464	.963	7.164	1.584
Protoxide of manganese	.260	.446	.781	.353
Sulphuric acid	.135	.052	.080	.149
Potash	1.425	1.317	2.047	1.892
Soda	.130	.275	.271	.162
Loss	1.504	----------	.163	----------
	100.000	100.274	100.000	101.740
Proportion of oxygen in the *bases* to the oxygen in the *silica*,	As 12.258:30.050 or As 1:2.451	As 12.495:32.182 or As 1:2.575	As 10.692:33.688 or As 1:3.150	As 11.599:34.021 or As 1:2.941

The considerable loss of iron, in the form of protoxide, as shown in the analyses of Nos. 905 and 907, would be avoided by the use of more lime in the flux.

In the analyses of these slags, it will be seen that the proportion of *sulphur* (sulphuric acid) is estimated. Doubtless, much of this injurious ingredient may occasionally be thus carried off, where the alkalies and alkaline earths are in large proportion in the flux. As to the quantity of phosphoric acid removed in this manner, the estimation was not made in these analyses. This is, however, a question of great importance, especially in relation to the quality of the iron made with more or less limestone to the flux.

ORES, &c., FROM HURRICANE FURNACE.

No. 909—LIMONITE. *Labeled "Block Ore, (No. 1,) found in 'nests' or beds five to seventy-five feet below the surface. Banks about a mile and a quarter from Hurricane Furnace, (formerly Jackson Furnace,) Crittenden county, Ky."*

This and the next ore ('honey-comb ore') are principally used at this furnace; say about three fourths. Obtained by Mr. John Bartlett.

A dense, dark-brown limonite, in irregular shaped masses; cellular in the interior; coated with ochreous ore of a rich reddish-yellow color. Powder of a dark, brownish-yellow color.

No. 910—LIMONITE. *Labeled "Honey-comb Ore, (No. 2,) Hurricane Furnace, Crittenden county, Ky., &c."*

The dense hard layers are in smaller proportion to the handsome yellowish ochreous ore than in the preceding specimen. This being mostly composed of soft ochreous ore. Powder of a light, brownish-yellow color.

No 911—LIMONITE. *Labeled "Pipe Ore, (No. 3,) Hurricane Furnace, Crittenden county, Ky."*

A dense, dark-brown limonite, adhering slightly to the tongue; mainly made up of adhering, tuberculated, columnar, or stalactite concretions; with some light, reddish-brown and yellow, ochreous ore between. Powder of a dark, brownish-yellow color.

No. 912—LIMONITE. *Labeled "Pot Ore, (No. 4,) Hurricane Furnace, Crittenden county, Ky."*

Irregular shaped, hollow masses, or geodes, of dark-brown limonite,

incrusted with dirty, yellowish-brown ochreous ore. Dense portion does not adhere to the tongue. Powder of a dark, brownish-yellow color.

No. 913—LIMONITE. *Labeled "Slate Ore, (No. 5,) Hurricane Furnace, Crittenden county, Ky."*

A portion of a flat layer, about half an inch thick, of brown limonite, not adhering to the tongue; coated on both sides with yellow ochreous ore. Powder of a light, brownish-yellow color.

No. 914—LIMONITE. *Labeled "Sand Ore, (No. 6,) Hurricane Furnace, Crittenden county, Ky.," &c.*

Dark, reddish-brown, with darker spots; granular; containing sand. Powder of a rich, brownish-yellow color.

COMPOSITION OF THE PRECEDING SIX ORES, DRIED AT 212° F.

	No. 909. Block ore.	No. 910. Honey-comb ore.	No. 911. Pipe ore.	No. 912. Pot ore.	No. 913. Slate ore.	No. 914. Sand ore.
Oxide of iron	80.940	56.840	82.540	83.060	84.640	25.940
Alumina	.420	8.980	.580	.480	.580	.580
Lime	trace.	trace.	trace.	trace,	trace.	trace.
Magnesia	.713	.936	.541	.513	.471	.654
Brown oxide of manganese	.280	.320	.240	.240	.680	.180
Phosphoric acid	.438	.591	.502	trace.	.464	trace.
Sulphuric acid	.200	.040	.083	.248	.097	.132
Potash	.200	.301	.162	.135	.143	.189
Soda	trace.	trace.	.076	.104	.145	trace.
Silex and insoluble silicates	7.380	20.880	5.380	4.080	2.920	68.180
Combined water	10.000	11.600	10.560	11.600	10.800	3.400
Loss						.745
Total	100.571	100.488	100.664	100.460	100.940	100.000
Percentage of iron	56.684	39.806	58.014	58.168	59.275	18.166
Moisture, lost at 212° F.	0.70	1.60	1.00	0.50	0.50	0.40

These ores are all quite rich, except the "sand ore;" which may very well be used in mixture with some of the richer sorts. The pot ore seems to contain the least phosphoric acid amongst the richer specimens. All are devoid of any marked quantity of *lime*. (See, under the head of Trigg county, the examination of some of the water and sediment obtained from the interior of the "pot ore" of this region.)

No. 915—LIMESTONE. *Labeled "Blue Limestone used as a flux (good) at Hurricane Furnace, Crittenden county, Ky. Found near the Furnace."* (*Obtained by Mr. John Bartlett.*)

A fine-grained, dark lead-colored limestone; containing fossil shells, and sparkling with facets of calc. spar.

Dried at 212° F., it lost 0.10 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	79.380=50.156 per cent. of lime
Carbonate of magnesia	8.468
Alumina, and oxides of iron and manganese	2.580
Phosphoric acid	a trace.
Sulphuric acid	.587
Potash	.353
Soda	.233
Silex and insoluble silicates	7.580
Loss	.919
	100.000

This limestone contains but little phosphoric acid, which is in its favor as a flux for iron; but it would be better did it contain less sulphuric acid.

No. 916—SANDSTONE. *Labeled "Sandstone used for the bosh and inner wall, at Hurricane Furnace, Crittenden county, Ky. Found two miles from the furnace."* (*Obtained by Mr. John Bartlett.*)

A moderately firm, fine-grained sandstone; colored more or less with oxide of iron, in bands.

No. 917—SANDSTONE. *Labeled "Hearthstone, found two miles from Hurricane Furnace, &c."*

Coarser grained than the preceding; quite friable; less colored with oxide of iron. Composed of rounded grains of nearly clear quartz, with no other cement than oxide of iron.

No. 918—SANDSTONE. *Labeled "Hearthstone, (superior,) from the same locality as the last, &c."*

Firmer and coarser-grained than the preceding; containing small rounded quartz pebbles, and peroxide of iron in spots.

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COMPOSITION OF THESE THREE SANDSTONES, DRIED AT 212° F.

	No. 916.	No. 917.	No. 918.
Sand and insoluble silicates	97.400	98.580	98.640
Alumina, and oxides of iron and manganese	.980	.640	.580
Lime	trace.	trace.	trace.
Magnesia	.566	.666	.266
Phosphoric acid	trace.	trace.	trace.
Sulphuric acid	trace.	trace.	trace.
Potash	.213	.231	.212
Soda	.156	.124	.028
Loss, and water expelled at red heat	.685	.240	.400
Total	100.000	100.481	100.126
Moisture, lost at 212° F.	0.20	0.30	0.40

That sandstone which is the most esteemed for resisting the action of the strong heat of the furnace, is the purest; containing less of foreign materials with its clear quartz sand than any of the others.

No. 919—PIG IRON. *Labeled "Grey Iron, (not dead grey,) for forging and foundry purposes. Hurricane Furnace, Crittenden county, Ky."* (*Obtained by Mr. John Bartlett.*)

A coarse-grey, specular, grey iron. Yields easily to the file. Small fragments break easily under the hammer.

No. 920—PIG IRON. *Labeled "Lively-grey Iron, Hurricane Furnace, &c., &c."*

Somewhat finer-grained, and a little lighter colored than the preceding. Yields easily to the file. Small fragments flatten somewhat under the hammer, but soon break to pieces.

No. 921—PIG IRON. *Labeled "White Iron, Hurricane Furnace, &c., &c."*

Very hard, and difficult to break; tougher than white iron generally. Yields with difficulty to the file. Fracture presenting a confused, bladed, semi-crystalline appearance, radiating from the under side of the pig.

No. 922—PIG IRON. *Labeled "Iron intermediate between White Iron and Lively-grey. Hurricane Furnace, &c., &c."*

A moderately fine-grained, light-grey iron. Yields with some difficulty to the file. Small fragments extend a little under the hammer, but soon break to pieces.

COMPOSITION OF THESE FOUR SPECIMENS OF IRON.

	No. 919.	No. 920.	No. 921.	No. 922.
Iron	91.871	92.143	92.263	92.336
Graphite	2.040	2.624	.984	2.224
Combined carbon	2.284	1.560	5.360	2.860
Manganese	.172	.433	.417	.345
Silicon	2.180	2.065	.142	.624
Slag	.184	.284	.184	.084
Aluminum	.202	.170	.202	.149
Calcium	trace.	trace.	trace.	trace.
Magnesium	.368	.348	.328	.220
Potassium	.064	.048	.105	.089
Sodium	.054	.082	.177	.012
Phosphorus	.727	.540	.464	.446
Sulphur	.066	.066	.108	not estim'd
Loss	----------	----------	----------	.611
Total	100.212	100.363	100.734	100.000
Total carbon	4.324	4.184	6.344	5.034
Specific gravity	7.0657	7.1060	7.9263	7.2778

The iron from Hurricane furnace has maintained a good character for softness and toughness. By the following analyses of the slags from this furnace, it will be seen that they have a larger proportion of *bases* to the silica, especially of lime, magnesia, and alumina, than is contained in the Crittenden furnace "cinders," reported above.

No. 923—IRON FURNACE SLAG. *Labeled "Slag from the grey iron, Hurricane Furnace, Crittenden county, Ky."* (*Obtained by Mr. John Bartlett.*)

A glossy, dark-bluish-smoky slag; translucent on the thin edges. A portion of the lump is opake and blebby, and is of an olive-grey color. Before the blow-pipe, in the oxidating flame, it easily melts into a blebby globule.

No. 924—IRON FURNACE SLAG. *Labeled "Slag from the lively grey iron, Hurricane Furnace," &c., &c.*

A dark glossy slag; of a smoky black color; translucent on the thin edges. Before the blow pipe, in the oxidating flame, easily melting into a blebby globule.

No. 925—IRON FURNACE SLAG. *Labeled "Slag from the white iron, Hurricane Furnace, &c., &c."*

A dark, bottle green blebby slag; translucent on the thin edges. Before the blow-pipe, melts quite easily into a dark bottle-green globule.

No. 926—IRON FURNACE SLAG. *Labeled "Slag from iron intermediate between white and lively grey, Hurricane Furnace, &c., &c."*

A frothy greenish-grey slag; full also of large bubbles, some of which are incrusted with oxide of iron. Before the blow-pipe it melts easily into a frothy globule.

The formation of bubbles in the dense slags, when fused in the oxidating flame of the blow-pipe, is doubtless owing to the oxidation of the involved smoky, or carbonaceous matters, which give to it the fuliginous color. In the slag from the white iron, this *oxidation* seems to have taken place in the furnace; by an excess of the blast, perhaps.

THE COMPOSITION OF THESE SLAGS IS AS FOLLOWS:

	No. 923.	No. 924.	No. 925.	No. 926.
Silica	55.380	55.580	56.980	59.980
Alumina	14.440	13.380	13.280	11.880
Lime	25.578	25.241	16.936	21.066
Magnesia	3.304	3.660	2.845	2.566
Protoxide of iron	1.494	1.854	10.495	4.014
Protoxide of manganese	trace.	trace.	trace.	trace.
Potash	1.815	1.495	1.398	1.151
Soda	.173	.199	.016	.388
Total	102.184	101.409	101.950	102.045
Proportion of oxygen in the bases to oxygen in the silica	As 16.017:28.755 or As 1:1.798	As 15.611:28.859 or As 1:1.848	As 14.729:29.585 or As 1:2.008	As 14.154:31.143 or As 1:2.200

It is instructive to observe, in the above slags, how the proportion of protoxide of iron, (and consequent waste of metal,) increases as the quantity of lime is diminished. That which was formed with the "white iron" contains the least lime of all. These slags approach to *bi-silicates* in their composition; whilst those of Crittenden furnace are nearly *tri-silicates.*

No. 927—CLAY. *Labeled "Clay; found plenty near Hurricane Furnace. (Is it fire clay?) Crittenden county, Ky."*

Of a light greenish-grey color. Before the blow-pipe it melts with difficulty into a whitish slag.

Dried at 212° it lost 4.00 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Silica	62.280
Alumina	18.880
Oxide of iron	3.560
Lime	.325
Magnesia	1.815
Phosphoric acid	.115
Potash	3.358
Soda	trace.
Water and loss	9.667
	100.000

This contains too much of the alkalies and alkaline earths to prove a very refractory fire-clay. But it would answer exceedingly well for a potter's clay.

No. 928—SILICIOUS CONCRETION. "*Found in the preceding clay, at Hurricane Furnace, &c., &c.*" *Sent for examination.*

Porous; and in some parts presenting some appearance of fossil remains.

COMPOSITION, DRIED AT 212° F.

Silex and insoluble silicates	96.980
Alumina, and oxides of iron and manganese	.680
Lime	trace.
Magnesia	.599
Phosphoric acid	not estimated.
Sulphuric acid	.058
Potash	.162
Soda	.129
Water and loss	1.392
	100.000

Of no especial interest.

No. 929—COAL. *Labeled "Cannel part of Coal of Sneed's mine, Tradewater river, Crittenden county, Ky."*

A handsome, pitch-black coal; with a bird's-eye, or curled maple like structure on the cross-fracture. No fibrous coal between the layers; and very little pyrites, in thin patches.

Over the spirit lamp, it burnt with considerable flame; swelled up and agglutinated, somewhat, into a cellular coke. Specific gravity, 1.297.

PROXIMATE ANALYSIS.

Moisture	1.00	Total volatile matters	37.50
Volatile combustible matters	36.50		
Fixed carbon in the coke	51.90	Spongy coke	62.50
Light yellowish-grey ash	10.60		
	100.00		100.00

Its composition and properties hardly entitle it to the name of a *cannel coal.*

Its percentage of *sulphur* is 0.686.

COMPOSITION OF THE ASH.

Silica	6.244
Alumina, and oxides of iron and manganese	3.080
Lime	.384
Magnesia	.260
Phosphoric acid	.300
Sulphuric acid	.012
Potash and soda, notable quantities	not estimated.
	10.280

DAVIESS COUNTY.

No. 930—LIMESTONE (HYDRAULIC ?) *Labeled "Limestone from a well, seven miles east of Owensboro, Daviess county, Ky."*

A dull, dark, greenish-grey, fine-grained limestone; mottled with darker; full of fossils—corals, encrinites and shells.

Dried at 212° F., it lost 0.50 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	37.900
Carbonate of magnesia	16.665
Alumina, and oxides of iron and manganese	10.440
Phosphoric acid	.207
Sulphuric acid	3.155
Potash	.366
Soda	.063
Silex and insoluble silicates	28.320
Water and loss	2.884
	100.000

This, if properly prepared, would no doubt make good hydraulic cement.

EDMONSON COUNTY.

No. 931—LIMONITE. *Labeled "Nautilus sp? Nolin Furnace, Edmonson county, Ky. How much iron?"*

The fossil shell or cast of a nautilus, completely filled, and mineralized, with oxide of iron. Quite friable; adheres to the tongue. Color brownish-yellow and dark brown.

Dried at 212° F., it lost 1.70 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	37.240=26.039 per cent. of iron.
Alumina	2.057
Carbonate of lime	1.180
Magnesia	.419
Brown oxide of manganese	.680
Phosphoric acid	2.423
Sulphuric acid	.544
Potash	.201
Soda	.066
Silex and insoluble silicates	45.520
Combined water and loss	9.670
	100.000

ESTILL COUNTY.—ORES, &c., OF COTTAGE FURNACE.

No. 932—LIMONITE. *Labeled "Block Ore; worked at Cottage Furnace, Estill county, Ky."*

Friable; dark-brown, irregular layers of dense ore, (not adhering to the tongue,) involving yellowish and reddish ochreous ore. Powder yellowish-brown.

No. 933—LIMONITE. *Labeled "Speckled Pink Ore; worked at Cottage Furnace, Estill county, Ky."*

Granular; adhering to the tongue; under the lens appearing to be made up of dark red grains, with intervening yellowish material. General color grey-brown, with shades of yellow and red. Powder reddish-brown.

No. 934—LIMONITE. *Labeled "Rough Ore; worked at Cottage Furnace, Estill county, Ky. Superior quality; makes high white iron."*

Irregularly laminated and cellular dark brown dense ore, including dirty-yellow ochreous ore. Powder yellowish brown.

No. 935—LIMONITE. *Labeled "Kidney Ore, over the Sandstone, thirty feet above the main Ore, Cottage Furnace, &c., &c."*

A brownish-yellow, friable ore, laminæ and cells of denser, dark-brown ore. Adhering to the tongue. Powder yellowish-brown.

No. 936—LIMONITE. *Labeled "Ore from the Buzzard Banks of Cottage Furnace, &c., &c. (Does it contain copper?")*

A friable, dark, grey-brown ore, with portions of dirty, greenish-yellow; adhering to the tongue. Under the lens it exhibits fine rounded grains of dark brown color, with a lighter colored material intervening. Powder of a yellowish-brown color, darker than the preceding.

COMPOSITION OF THESE FIVE LIMONITE ORES, DRIED AT 212° F.

	No. 932. Block ore.	No. 933. Speckled ore.	No. 934. Rough ore.	No. 935. Kidney ore.	No. 936. Buzzard Bank ore.
Oxide of iron	60.800	66.140	52.454	45.540	62.200
Alumina	3.060	1.460	.660	3.496	.440
Lime	trace.	trace.	trace.	trace.	trace.
Magnesia	.642	.803	.852	1.028	2.742
Brown oxide of manganese	2.360	1.140	2.480	.980	1.620
Phosphoric acid	.800	.310	.740	.925	.502
Sulphuric acid	.107	.213	.107	.145	.135
Potash	.413	.405	.366	.434	.508
Soda	.185	.053	.167	.190	.192
Silex and insoluble silicates	21.360	22.360	33.980	39.080	21.080
Combined water	10.540	7.560	8.900	8.700	10.760
Total	100.267	100.444	100.506	100.518	100.179
Percentage of iron	42.635	46.303	36.755	31.891	43.559
Moisture lost at 212° F.	2.860	3.100	1.600	----------	----------

All good, and sufficiently rich ores. With the exception of the "rough ore," those which contain the most phosphoric acid also possess the largest quantity of alumina; which tends, more perhaps than any other base, to carry off this injurious ingredient in the cinder.

No. 937—CARBONATE OF IRON. *Labeled "Grey Ore, associated with the 'Rough Ore,' Cottage Furnace, Estill county, Ky."*

A grey, fine-granular carbonate of iron; not adhering to the tongue. Weathered surfaces of a dark reddish-brown color. Powder light grey buff. Specific gravity, 3.5762.

No. 938—CARBONATE OF IRON. *Labeled "White Ore, from the Buzzard Bank, Cottage Furnace, &c." Sub-carboniferous.*

Interior, grey, with a few small white specks; granular, adhering slightly to the tongue. *Exterior*, dark brown; adhering to the tongue; in parts presenting irregular bladed shining facets like those of some forms of zinc blende. Powder of a brownish-yellow color.

COMPOSITION OF THESE TWO CARBONATES OF IRON, DRIED AT 212° F.

	No. 937. Grey ore.	No. 938 White ore.
Carbonate of iron	78.086	54.147
Oxide of iron	1.050	16.197
Alumina	2.460	1.160
Carbonate of lime	1.290	6.190
Carbonate of magnesia	4.508	3.885
Carbonate of manganese	3.492	2.680
Phosphoric acid	.438	.438
Sulphuric acid	.176	.303
Potash	.231	.250
Soda	.198	.321
Silex and insoluble silicates	8.670	13.120
Water and loss	---------	1.309
Total	100.599	100.000
Percentage of iron	38.461	37.495
Moisture, expelled at 212° F.	0.400	---------

These are both very good iron ores; requiring only careful roasting and management of the flux to yield good iron. They are sufficiently rich for profitable smelting; as the *roasted* ores would contain fifty per cent. of metal.

No. 939—LIMESTONE. *Labeled "Sub-carboniferous Limestone, used as a flux at Cottage Furnace, Estill county, Ky."*

A grey, fine-granular limestone; with some blotches of dirty-buff color; no appearance of fossils. Specific gravity 2.6828.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	92.020=50.515 per cent. of lime.
Carbonate of magnesia	.629
Alumina, and oxides of iron and manganese	1.120
Phosphoric acid	.310
Sulphuric acid	.166
Potash	.193
Soda	.083
Silex and insoluble silicates	4.580
Water and loss	.899
	100.000

Dried at 212° F., it lost 0.40 per cent. of *moisture.*

No. 940—IRON FURNACE SLAG. *Labeled "Purple Slag, produced at Cottage Furnace when making soft iron, Estill county, Ky."*

A glassy, dark, smoky-purple slag; transparent on the thin edges, and in thin splinters. Before the blow-pipe, it is easily fusible, with intumescence.

No. 941—IRON FURNACE SLAG. *Labeled "Green Slag, produced at Cottage Furnace when working 'rough ore' and 'high white' iron, Estill county, Ky."*

A greenish-grey, frothy slag; inflated with air-bubbles and containing many particles of reduced iron. Before the blow-pipe easily fused into a greenish globule.

COMPOSITION OF THESE TWO SLAGS.

	No. 940. Purple slag.	No. 941. Green slag.
Silica	56.300	58.040
Alumina	16.100	12.360
Lime	21.414	18.058
Magnesia	1.845	1.333
Protoxide of iron	1.170	6.122
Protoxide of manganese	.595	1.060
Potash	1.757	1.970
Soda	.190	.309
Phosphoric acid	.654	.117
Loss		.631
Total	100.025	100.000
Proportion of oxygen in the *bases* to oxygen in the *silica*,	As 15.070:29.232 or As 1:1.930	As 12.496:30.136 or As 1:2.331

In these slags, the presence of *phosphoric acid* was verified and the amount in each estimated. It is a fact of great importance to the iron manufacturer, that this injurious ingredient may be carried off more or

less in the cinder; and it is interesting to note, in the above analyses, that the slag which contains the most *lime* and *alumina*, (especially of alumina,) also has the largest proportion of phosphoric acid, although the "*rough ore*," used in the production of the *green slag*, is probably more contaminated with this acid than the ores employed when *purple slag* was formed. It has generally been believed and asserted by the authors, even by Karsten, that, in consequence of the strong affinity existing between phosphorus and iron, in the melted state, almost all the phosphoric acid in the mixture of ores, flux, &c., in the high furnace, reduced to phosphorus by the excess of carbonaceous matters present, would find its way into the iron; communicating to it "*cold short*" properties. But the affinity between phosphoric acid and *alumina* is quite strong; and, very probably, tends more to counteract its reduction and union with the melted iron than any other agency present. Hence one reason perhaps, why the aluminous ores generally give tough iron; and why, also, the addition of pure clay or aluminous earth, or ores, will improve the toughness of iron made from "cold short" (or phosphatic) ores. This idea, if fully verified in practice, will prove of very great value to the smelter of iron.

Another fact will be noted in the analyses of these slags, viz: that the loss of iron in the form of *protoxide* is greater in the *green slag*, which contains the least *lime* and *alumina*, than in the other. This makes the cinder more fluid, causing what is called *scouring* of the furnace, and gives it the bottle-green color, sometimes very dark.

It will also be observed in the following analyses of the iron made with these two slags, that the "white iron," made with the *green slag*, contains the most *phosphorus* and *sulphur*.

No. 942—Pig Iron. *Labeled "Soft Iron, produced at Cottage Furnace, when making dark, purple slag, Estill county, Ky."*

A dark-grey, fine-granular iron; yields easily to the file; flattens somewhat under the hammer, but soon breaks.

No. 943—Pig Iron. *Labeled "High White Iron, produced when working rough ore, and making green slag, Cottage Furnace, Estill county, Ky."*

A little harder, coarser grained, and lighter colored than the preceding, but not much. Yields to the file, and flattens a little under the hammer. It cannot properly be called a *high white iron*. It is rather *grey* iron.

COMPOSITION OF THESE TWO SAMPLES OF PIG IRON.

	No. 942 Soft Iron.	No. 943 High White Iron.
Iron	93.689	93.793
Graphite	3.150	3.220
Combined carbon	.610	.550
Manganese	.689	.548
Silicon	.989	.793
Slag	.320	.260
Aluminum	.047	.055
Calcium	trace.	trace.
Magnesium	.258	.235
Potassium	.068	not estimated.
Sodium	.098	----------
Phosphorus	.344	.474
Sulphur	.060	.120
Total	100.322	100.084
Total carbon	3.760	3.770
Specific gravity	7.1117	7.1212

No. 944—Limonite. *Labeled "Old Furnace Ore Banks, Estill county, Ky."* (*Sub-carboniferous.*)

A dense, fine-grained, yellowish-brown ore, with streaks of lighter and darker color; dull, with some minute specks of mica. Adheres to the tongue. *Specific gravity*, 2.9131.

No. 945—Limonite. *Labeled "Old Furnace Ore Banks, Estill county, Ky."* (*Sub-carboniferous.*)

An irregularly rounded mass, made up of irregular, thin layers of dark brown and bluish-black, involving soft brownish-yellow ochreous ore. Powder dark brownish-yellow.

COMPOSITION OF THESE TWO LIMONITES, DRIED AT 212° F.

	No. 944.	No. 945.
Oxide of iron	71.600	62.480
Alumina	.520	3.349
Carbonate of lime	.680	trace.
Magnesia	1.408	.513
Brown oxide of manganese	1.680	.920
Phosphoric acid	.822	.591
Sulphuric acid	.303	.372
Potash	.494	.714
Soda	.202	.143
Silex and insoluble silicates	11.120	20.580
Combined water	11.200	10.800
Total	100.029	100.462
Percentage of iron	50.042	43.756
Moisture, lost at 212° F.	2.010	1.700

Both good ores. The second, No. 945, would probably make the tougher iron of the two.

A collection of the ores, pig iron, slag, fire-clay, and limestone, used at Estill furnace, as sent to this laboratory by the enterprising proprietors, but time did not permit their analysis in season for this report.

No. 946—CLAY. *Labeled "Potter's Clay? four miles northwest of Irvine, on the Richmond turnpike, Estill county, Ky."*

Of a light buff-grey color, with stratified lines of reddish. Before the blow-pipe it is not evidently fusible. Changes to handsome salmon-color in burning. Appears to be, principally, fine quartzose sand; sparkling with a few minute scales of mica.

COMPOSITION, DRIED AT 212° F.

Silica	71.780
Alumina	17.580
Oxide of iron	2.420
Lime	none.
Magnesia	.547
Sulphuric acid	.112
Potash	2.271
Soda	.322
Water expelled at red heat	4.400
Loss	.568
	100.000

Quite a refractory clay; but probably not sufficiently so to be a *very good* fire clay. It will answer exceedingly well for the use of the potter.

No. 947—LIMESTONE (HYDRAULIC?) *Labeled "Building Stone, five miles from Irvine, on the Richmond Turnpike, Estill county, Ky." (Upper Silurian formation.)*

A dark-grey, fine-grained limestone, containing many small scales of mica. Does not adhere to the tongue.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	41.380	=23.221 lime.
Carbonate of magnesia	30.019	
Carbonate of iron	4.321	
Oxide of iron	2.360	
Alumina	.806	
Brown oxide of manganese	.480	
Phosphoric acid	.374	
Sulphuric acid	1.471	=.590 sulphur.
Potash	.482	
Soda	.019	
Silex and insoluble silicates	18.680	
	100.392	

There is but little doubt that this would make very good hydraulic

cement, if properly burnt and prepared; but it is not so probable that it would prove a durable building stone. Rocks containing so much *carbonate* of *iron* and so much *sulphur*, are liable to disintegration when exposed to the atmospheric influences.

No. 948—CARBONATE OF IRON. *Labeled "Carbonate of Iron from the ash-colored shales, above the Black Devonian Slate. Red Lick Fork of Station Camp Creek, Estill county, Ky."*

Fine-granular; grey in the interior; light brownish-buff and reddish-brown on the exterior. Does not adhere to the tongue. Powder of a buff-grey color.

Dried at 212° F., its powder lost 0.40 per cent. of *moisture*.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	64.210	=34.203 iron.
Oxide of iron	4.543	
Alumina	.580	
Carbonate of lime	1.920	
Carbonate of magnesia	9.335	
Carbonate of manganese	2.077	
Phosphoric acid	.464	
Sulphuric acid	.200	
Potash	.424	
Soda	.281	
Silex and insoluble silicates	13.180	
Water and loss	2.796	
	100.000	

A very good ore, sufficiently rich for profitable smelting.

No. 949—LIMESTONE (HYDRAULIC?) *Labeled "Argillaceous Limestone, (hydraulic?) below the magnesian building stone at the Covered Rock, three miles below Irvine, Estill county, Ky."*

A fine-grained rock of a greenish-grey color; not adhering to the tongue. Powder, light greenish-grey. Specific gravity 2.7163.

No. 950—LIMESTONE (HYDRAULIC?) *Labeled "Limestone Shale, (hydraulic?) Covered Rock, three miles below Irvine, Estill county, Ky."*

A brownish-black, fine-granular rock. Flat conchoidal fracture. Not adhering to the tongue. Powder of a dirty-buff, or light-umber color.

No. 951—LIMESTONE (HYDRAULIC?) *Labeled "Hydraulic Limestone? two miles west of Red River Iron Works, Estill county, Ky. (Devonian.")*

A brownish-black, or dark-umber colored, fine-granular rock; easily broken. Does not adhere to the tongue. Powder of a light-umber color.

COMPOSITION OF THESE THREE LIMESTONES, DRIED AT 212° F.

	No. 949. Argillaceous Limestone.	No. 950. Limestone Shale.	No. 951. Hydraulic Limestone.
Carbonate of lime	27.980	37.480	36.580
Carbonate of magnesia	19.022	22.927	19.792
Alumina, and oxides of iron and manganese	9.660	6.160	6.260
Phosphoric acid	.246	.182	.079
Sulphuric acid	.544	1.368	1.561
Potash	.618	.695	.482
Soda	.296	.372	.231
Silex and insoluble silicates	38.480	28.580	28.240
Water and loss	3.154	2.236	*6.775
Total	100.000	100.000	100.000
Moisture lost at 212° F.	0.700	0.700	0.740

Although these limestones contain more silicious and aluminous matters than the best water limes, they are all worthy of trial as hydraulic cement.

MINERAL WATERS OF ESTILL SPRINGS.

No. 952—MINERAL WATER. *Labeled "Red Sulphur Water, near the Saloon. Estill Springs, near Irvine, Estill county, Ky."*

No. 953—MINERAL WATER. *Labeled "White Sulphur Water, at the Saloon, &c., &c."*

No. 954—MINERAL WATER. *Labeled "Chalybeate Water, northwest side of Sweet Lick Knob, &c., &c."*

No. 955—MINERAL WATER. *Labeled "Red Sulphur Water; four hundred yards east of the buildings at Estill Springs, &c."*

No. 956—MINERAL WATER. *Labeled "Black Sulphur Water, Estill Springs, &c."*

These waters were carefully bottled and sealed by Mr. S. S. Lyon, Topographical Assistant, and sent by stage to the laboratory, where they were examined with as little delay as possible. It was impossible, however, to avoid the loss of some of the gases, especially of sulphuretted hydrogen; and hence the estimation of the gaseous ingredients of these waters, given below, is doubtless too low in every case. To estimate fully the amount of the gaseous ingredients, the operations must be performed at the springs.

* This includes some *bituminous matters.*

COMPOSITION OF THESE ESTILL WATERS; IN 1000 PARTS OF THE WATER.

	No. 952. Red Sulphur.	No. 953. White Sulphur.	No. 954. Chalybeate.	No. 955. Red Sulphur.	No. 556 Black Sulphur.
Carbonic acid gas	0.3256	0.360	0.269	0.228	0.263
Sulphuretted hydrogen gas	.0045	.003	—	.012	.035
Carbonate of lime	0.2020	0.303	0.159	0.021	0.113
Carbonate of magnesia	.0832	.011	.046	.025	.027
Carbonate of iron	—	—	.032	trace.	.069
Carbonate of soda	.0237	.083	—	—	—
Chloride of sodium	.0842	.009	.009	.099	.036
Chloride of calcium	—	—	—	.106	—
Sulphate of lime	—	—	.286	—	—
Sulphate of magnesia	.0105	.105	.168	.035	.018
Sulphate of soda	.1723	.043	.012	—	.035
Sulphate of potash	.0926	.072	.011	.011	.017
Sulphate of alumina	—	—	—	—	.023
Alumina and trace of phosphates	—	.016	trace.	—	—
Organic and volatile matters	.0400	.050	.141	.044	.059
Silica	.0068	.004	.032	.029	.013
Saline matters in 1000 parts of the water	0.7153	0.696	0.896	0.370	0.410

The carbonates of lime, magnesia, and iron are held in solution by the free carbonic acid; or, in other words, exist in the waters as *bi-carbonates*. The soda is also in the form of bi-carbonate, which salt is not incompatible with the sulphate of magnesia present in the same water.

The chalybeate water owes its name and peculiar virtues to its bi-carbonate of iron, of which the red sulphur water, most distant from the house, contains traces, (as doubtless the other also,) and the "black sulphur" even more than the chalybeate, (as tested at the laboratory.) The latter contains a small proportion of sulphate of alumina, (alum.) The change of the dissolved *bi-carbonate of protoxide of iron* to *insoluble hydrated peroxide of iron*, which always takes place when these waters are exposed to the air, is the cause of the formation of the brownish deposit, and their loss of virtues, when they are carried any distance from the spring.

No. 957—MINERAL WATER. *Obtained by D. C. Winburn, from where he formerly procured the Copper Ore, (described in Vol. II of these Reports,) near Irvine, Estill county, Ky.*"

SALINE MATTERS IN 1000 PARTS OF THE WATER.

Carbonate of lime	0.527	Held in solution by carbonic acid.
Carbonate of magnesia	.044	
Carbonate of iron	.025	
Sulphate of lime	.547	
Sulphate of magnesia	4.515	
Sulphate of potash	.043	
Chloride of sodium	.302	
Chloride of calcium	.029	
Silica	.069	
Water of crystallization and loss	1.473	
	7.572	

This water nearly resembles some of the Epsom Spring waters found in the neighborhood of Crab Orchard, Lincoln county.

No. 958—SOIL. *Labeled "Soil, from a cultivated field; from and immediately resting on Black Devonian Slate. Thos. H. Carson's farm, Irvine, Estill county, Ky., (grows excellent corn.") (Obtained by Dr. Owen.)*

Dried soil of a dark-umber color. It contains numerous fragments of soft dark-umber colored shale, which were sifted out before the analysis was made.

One thousand grains of the air-dried soil, digested for a month in water, charged with carbonic acid, gave up more than three grains of *dark chestnut-brown extract*, dried at 212° F., which had the following

COMPOSITION, VIZ:

Organic and volatile matters	0.547
Alumina, and oxides of iron and manganese and phosphates	.320
Carbonate of lime	1.430
Magnesia	.162
Sulphuric acid	.025
Potash	.077
Soda	.059
Silex and insoluble silicates	.231
Loss	.206
	3.057 grains.

The air-dried soil lost 4.275 per cent. of *moisture*, at 400° F.; dried at which temperature its *composition* is as follows, viz:

Organic and volatile matters	10.942
Alumina	3.290
Oxide of iron	6.635
Carbonate of lime	.420
Magnesia	.392
Brown oxide of manganese	.145
Phosphoric acid	.347
Sulphuric acid	.578
Potash	.697
Soda	.309
Sand and insoluble silicates	74.895
Loss	1.350
	100.000

This is quite a rich soil, containing a large quantity of potash, in particular; derived no doubt from the black slate which produced it, as the following analysis will show:

No. 959. "*Devonian Black Slate, sifted out of the preceding soil, from Thos. Carson's farm, near Irvine, Estill county, Ky.*"

COMPOSITION, DRIED AT 212° F.

Alumina, and oxides of iron and manganese	6.860
Carbonate of lime	.244
Magnesia	.433
Phosphoric acid	.310
Sulphuric acid	.132
Potash	1.101
Soda	.340
Sand and insoluble silicates	82.280
Bituminous matters, water and loss	8.300
	100.000

The soft aluminous shales are very generally rich in potash, and where they are easily decomposable they yield a rich soil; subject, however, to be wet, heavy, or swampy, because of the considerable amount of clay present and imperfect natural drainage. When well drained, these lands may be made quite productive.

No. 960—SOIL. *Labeled "Virgin Soil, taken from north of the house of Mr. James Townsend, on Billy's creek, a branch of Miller's creek, Estill county, Ky. Geological position, on the terrace of sub-carboniferous limestone."*

Dried soil of a light yellowish-umber color. Fragments of ferruginous sandstone and gravel iron-ore were sifted out of it with the coarse seive.

No. 961—SOIL. *Labeled "Surface Soil from a field thirty-six years in cultivation; (twenty-five years in corn; never manured;) adjoining the house of Mr. James Townsend, on Billy's creek, &c., &c."*

Dried soil of a dark, dirty grey-buff color; lighter than the preceding. Contains fragments of ferruginous sandstone, and gravel iron ore, like the preceding.

No. 962—SOIL. *Labeled "Sub-soil from the preceding old field; James Townsend's farm, on Billy's creek, &c., Estill county, Ky."*

Dried soil of a greyish-buff color, lighter than the preceding.

Fragments of ferruginous *sandstone* and gravel iron ore sifted out of it. One thousand grains of each of these three soils, digested for a month in water charged with carbonic acid, gave up of *soluble matters*, as follows:

	No. 960. Virgin soil.	No. 961. Old field.	No. 962. Sub-soil.
Organic and volatile matters	1.617	1.100	0.333
Alumina, and oxides of iron and manganese and phosphates	1.030	.697	.063
Carbonate of lime	.320	1.230	.540
Magnesia	.180	.193	.061
Sulphuric acid	.039	.033	.022
Potash	.060	.157	.125
Soda	.020	.036	.045
Silica	.104	.198	.247
Loss	.696	.533	.097
Soluble extract, dried at 212° F., (grains)	4.066	4.077	1.533

THE COMPOSITION OF THESE THREE SOILS IS AS FOLLOWS, DRIED AT 212° F.:

	No. 960. Virgin soil.	No. 961. Old field.	No. 962. Sub-soil.
Organic and volatile matters	8.483	4.647	2.957
Alumina	6.750	4.536	5.110
Oxide of iron	3.210	2.270	2.910
Carbonate of lime	.030	.181	.096
Magnesia	.460	.451	.417
Brown oxide of manganese	.460	.310	.180
Phosphoric acid	.318	.274	.192
Sulphuric acid	.055	.033	.016
Potash	.408	.295	.316
Soda	.068	.086	.093
Sand and insoluble silicates	79.695	86.610	87.970
Loss	.063	.308	----------
Total	100.000	100.000	100.257
Moisture, lost at 400° F.	3.510	2.100	1.615

The original, virgin soil is quite a good soil, with the exception of a deficiency of lime, which, added in the form of top-dressings in the air-slacked state, would, no doubt, improve its fertility. The soil of the "old field" shows the usual diminution of most of the essential ingredients, as compared with the virgin soil.

No. 963—SOIL. *Labeled "Virgin Soil, from the top of Dividing Ridge, between Estill and Powell and Owsley and Powell counties, Ky. From near the Standing Rock. Not much cultivated at present, as the*

limestone valleys below are better for farms; good for grass. Geological position: on the conglomerate or millstone grit." (*This and the preceding three soils were obtained by Joseph Lesley, jr.*)

Dried soil, of a yellowish-grey color.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain and a half of dark umber-colored extract*, dried at 212°, which had the following

COMPOSITION, VIZ:

Organic and volatile matters	0.590
Alumina, and oxides of iron and manganese and phosphates	.420
Carbonate of lime	.097
Magnesia	.096
Sulphuric acid	.033
Potash	.090
Soda	.058
Silica	.194
Loss	.022
	1.600 grains.

The air-dried soil lost 1.125 per cent. of *moisture* at 400° F., dried at which temperature its *composition* is as follows:

Organic and volatile matters	2.680
Alumina	3.220
Oxide of iron	1.485
Carbonate of lime	.021
Magnesia	.297
Brown oxide of manganese	.110
Phosphoric acid	.128
Sulphuric acid	trace.
Potash	.166
Soda	.064
Sand and insoluble silicates	92.095
	100.266

One of the poorest soils of the State; yet susceptible of cultivation, if suitably located. The application of lime and plaster of paris would much increase its present productiveness.

No. 964—COAL. *Labeled* "*Coal, (under the conglomerate,) supposed to be twenty inches thick. Farm of Mr. James Townsend, Billy's Fork of Miller's Creek, Estill county, Ky.*" (*Obtained by Joseph Lesley, jr.*)

"It is said to be excellent for working steel, and small quantities have been 'packed' from the opening for that purpose."

A somewhat brittle, dark shining coal; cleaving into thin layers, which are coated with fibrous coal. Exterior stained with ochreous mud.

Over the spirit lamp, it softens and agglutinates; swells up considerably, and leaves a dense porous coke. Specific gravity 1.336.

PROXIMATE ANALYSIS.

Moisture	2.90	Total volatile matters	40.66
Volatile combustible matters	37.76		
Fixed carbon in the coke	50.84	Dense coke	59.34
Grey-purple ashes	8.50		
	100.00		100.00

The percentage of *sulphur* is 4.35.

COMPOSITION OF THE ASH.

Silica	1.884
Alumina and oxides of iron and manganese and phosphates	6.180
Lime	trace.
Magnesia	.233
Sulphuric acid	.077
Potash	.077
Soda	.147
	8.598

FAYETTE COUNTY.

No. 965—LIMESTONE. *Labeled "Lowest Rock at Clay's Ferry; below the bird's-eye limestone, Fayette county, Ky."*

A compact, light dove-grey, fossiliferous rock; fracture approaching conchoidal, containing specks of calc. spar, in some cases replacing fossil shells; presenting irregular veins of dirty yellowish-grey, less compact material.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	92.640
Carbonate of magnesia	3.999
Alumina, and oxides of iron and manganese	.440
Phosphoric acid	small trace.
Sulphuric acid	.441
Potash	not estimated.
Soda	not estimated.
Silex and insoluble silicates	2.480
	100.000

No. 966—MINERAL WATER. *"Sent by Rev. J. Bullock, from Walnut Hill, Fayette county, Ky., from a bored well of the depth of ninety feet in blue limestone of the Lower Silurian formation."*

The water contains free carbonic acid gas, and a small quantity of sulphuretted hydrogen. The amount of these gases was not estimated in the water sent to the laboratory for analysis.

SALINE CONTENTS IN 1000 PARTS OF THE WATER.

Carbonate of lime	0.126	Held in solution by carbonic acid.
Carbonate of magnesia	.045	
Carbonate of iron	trace.	
Carbonate of soda	trace.	
Chloride of sodium	4.012	
Chloride of potassium	.080	
Chloride of calcium	.014	
Chloride of magnesium	.317	
Sulphate of lime	.337	
Iodine	Marked traces; not estimated.	
Bromine		
Silica	.018	
	4.949	

A mild, salt-sulphur water, alkaline in its reaction.

No. 967—LIMESTONE. *Labeled "Magnesian Limestone, one hundred and ninety feet above low water. Stratum five feet thick; layers ten to eighteen inches thick, Raven Creek, Fayette county, Ky."* (*Obtained by Messrs. Downie and Lesquereaux.*)

A dull, fine-grained, homogeneous rock of a grey reddish-buff color; contains no fossils.

No. 968—LIMESTONE. *Labeled "Kentucky Marble, (Bird's-eye.) From Daniel Brink's quarry, fourteen and a half miles from Lexington, in Fayette county, Ky. Layer five and a quarter feet above Philip Brink's branch."* (*Obtained by Messrs. Downie and Lesquereux.*)

A compact warm light grey, brittle limestone, mottled with darker, and containing small veins of calc. spar.

No. 969—LIMESTONE. *Labeled, "Kentucky Marble, not so compact as the preceding. From Daniel Brink's quarry, twenty-six feet above Philip Brink's branch, Fayette county, Ky."* (*Obtained by Messrs. Downie and Lesquereux.*

A dull, fine-grained rock, dark warm-grey, mottled with darker bluish grey. Brittle.

No. 970—LIMESTONE. *Labeled "Coarse Fossiliferous Limestone, Daniel Brink's quarry, one hundred and one feet above Philip Brink's branch, Fayette county, &c., &c."*

A bluish-grey limestone, full of entrochites, broken bi-valve shells, coral, &c. Weathered surfaces dirty-buff.

These limestones are of the Lower Silurian formation.

COMPOSITION OF THESE FOUR LIMESTONES, DRIED AT 212° F.

	No. 967. Magnesian Limestone.	No. 968. Bird's-eye Limestone.	No. 969. Kentucky Marble.	No. 970. Fossiliferous Limestone.
Carbonate of lime	77.460	95.680	62.680	91.480
Carbonate of magnesia	15.426	2.044	23.079	1.044
Alumina, and oxides of iron and manganese	1.280	.380	6.060	3.980
Phosphoric acid	.246	.182	.246	.848
Sulphuric acid	.166	.166	.441	.317
Potash	.193	.193	.162	.232
Soda	.363	.048	.182	.336
Silex and insoluble silicates	2.980	1.580	5.280	2.380
Water and loss	1.886		1.870	
Total	100.000	100.273	100.000	100.617
Moisture, lost at 212° F.	0.010	0.010	0.006	0.010

A little more silica in the composition of the Kentucky marble No. 969, would make it a good water lime. The fossiliferous limestone would answer very well for use in agriculture; to be used as top-dressing to land deficient in phosphoric and sulphuric acids, lime, and the alkalies.

No. 971—Marly Clay. *From "Daniel Brink's place; one hundred and two feet above Philip Brink's branch, Fayette county, Ky." (Brought by Messrs. Downie and Lesquereux.)*

A light grey clay, mottled with buff.

COMPOSITION, DRIED AT 212° F.

Silica	56.880
Alumina, with some oxides of iron and manganese	24.656
Carbonate of lime	2.480
Carbonate of magnesia	3.276
Phosphoric acid	.182
Potash	6.655
Soda	.195
Water expelled at red heat and loss	5.676
	100.000

Contains an extraordinary quantity of potash, &c., and hence might profitably be used as a *marl*, on land which had been deteriorated by long cultivation.

For analyses of Catawba wine, and white wheat, produced in this county, see the appendix.

FLEMING COUNTY.

No. 972—Marl. *Labeled "Clay found at the junction of the Upper and Lower Silurian, of Fleming county, Ky."*

A greenish and reddish brown clay. Before the blow-pipe, melting at

the edges, and burning of light umber color. Powder light dirty-buff. Dried at 212°, it lost 1.20 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Silica	39.780
Alumina	10.401
Oxide of iron	10.760
Carbonate of lime	16.880
Magnesia	6.385
Brown oxide of manganese	1.084
Phosphoric acid	.079
Sulphuric acid	.338
Potash	1.147
Soda	not estimated
Water, expelled at a red heat	13.900
	100.754

May be employed as a marl on land, with the addition of bone dust, or *super-phosphate,* or other phosphatic material.

No. 973—MAGNESIAN LIMESTONE. *"Belonging to the age of the Clinton Groupe, Hillsborough, Fleming county, Ky."*

A dull, dirty-buff, impure limestone, containing entrochites, and exhibiting small specks of mica and brownish stains of oxide of iron. Powder of a greyish-buff color. Dried at 212° F., it lost 0.55 per cent. of *moisture;* and its *composition* is as follows:

Carbonate of lime	42.680	=23.951 per cent. of *lime.*
Carbonate of magnesia	25.358	
Carbonate of iron	5.155	
Carbonate of manganese	.421	
Oxide of iron	11.073	
Alumina	1.080	
Phosphoric acid	.848	
Sulphuric acid	.324	
Potash	.290	
Soda	.033	
Silex and insoluble silicates	10.880	
Water and loss	1.858	
	100.000	

This ferruginous, silicious, magnesian limestone, deserves trial as a water lime.

No. 674—LIMESTONE. *Labeled "Yellow-red Porous Rock, over the encrinital limestone, one and a half miles east of Mount Carmel, Fleming county, Ky."*

A dull, brownish-yellow, fine granular rock, glimmering with small crystalline facets of colored calc. spar., containing small cavities, or pores, some of which are infiltrated with carbonate of lime; others lined with dark colored oxide of iron. Adheres to the tongue. Powder of a buff color.

Dried at 212°, it lost 0.70 per cent. of *moisture*, and has the following

COMPOSITION :

Carbonate of lime	71.700
Carbonate of magnesia	9.931
Alumina, and oxides of iron and manganese	12.240
Phosphoric acid	.630
Sulphuric acid	.337
Potash	.341
Soda	.159
Silex and insoluble silicates	2.880
Water and loss	1.802
	100.000

No. 975—SOIL. *Labeled "Virgin Soil, derived from the yellow limestone. Charles Marshall's dairy farm, near Mount Carmel, Fleming county, Ky. (At the junction of the Lower and Upper Silurian formations.) Growth, sugar-tree, walnut, buck-eye, &c."*

Dried soil of a dark-grey-brown, or light chocolate color.

No. 976—SOIL. *Labeled "Soil from an old field twenty-five years in cultivation; the last eight years in grass. Charles Marshall's dairy farm, near Mount Carmel, Fleming county, Ky. (Upper Silurian formation."*

Dried soil a little lighter-colored than the preceding. Some rounded ferruginous particles were sifted out of it with the coarse seive.

No. 977—SOIL. *Labled "Sub-soil from the same old field, Chas. Marshall's dairy farm, &c., &c."*

Dried soil lighter-colored and more yellowish than the preceding.

One thousand grains of each of these (air-dried) soils, digested in water charged with carbonic acid, for about a month, gave up of *soluble extract*, dried at 212°, as follows:

	No. 975. Virgin soil.	No. 976. Old field.	No. 977. Sub-soil.
Organic and volatile matters	0.800	0.517	0.459
Alumina, and oxides of iron and manganese and phosphates	.147	.180	.150
Carbonate of lime	2.097	1.063	.880
Magnesia	.366	.245	.162
Sulphuric acid	.0[illegible]4	.022	.025
Potash	.135	.066	.042
Soda	.0[illegible]6	.033	.046
Silica	.231	.397	.347
Loss	.434	--------	--------
Soluble extract, dried at 212° F.	4.250	2.523	2.0[illegible]2

The *composition* of these three samples of soils, dried at 400° F., is as follows:

	No. 975. Virgin soil.	No. 976. Old field.	No. 977. Sub-soil.
Organic and volatile matters	11.315	7.335	* 7.675
Alumina	5.060	4.190	10.335
Oxide of iron	11.675	11.210	14.930
Carbonate of lime	.420	.395	.470
Magnesia	.874	.679	.868
Brown oxide of manganese	.290	.395	.370
Phosphoric acid	.251	.181	.236
Sulphuric acid	.084	.042	.059
Potash	.349	.202	.439
Soda	.224	.011	.050
Sand and insoluble silicates	69.145	75.645	64.995
Loss	.313		
Total	100.000	100.285	100.427
Moisture lost at 400° F.	5.525	4.225	6.650

The soil of the old field has undergone considerable deterioration. The sub-soil is as rich as the virgin soil.

The influence of dairy-farming upon the soil can be learnt by studying the composition of the *saline* portion of cows' milk. According to M. Haidlen, a thousand parts of fresh cow-milk contain:

Phosphate of lime	2.31	=about 1.33 *phosphoric* acid.
Phosphate of magnesia	.42	
Phosphate of iron	.07	
Chloride of potassium	1.44	=0.95 *potash*.
Chloride of sodium	.24	=0.55 *soda*.
Soda in combination with casein	.42	

It is easy, when we know how much milk is taken from the cows grazed on the land, to calculate how much of these essential ingredients are removed from the soil in a given time, in this manner.

The earthy phosphates and the alkalies are thus taken up in considerable quantities, and hence it has been found to be advantageous to apply top-dressings of powdered bones, or super-phosphates, with ashes, to ground which has been long used for pasturage for dairy purposes.

No. 978—SOIL. *Labeled "Virgin Soil, from blue ash land, on the Delthyris Lynx beds of the upper part of the blue limestone formation, (Lower Silurian.) Mr. Fitzgerald's farm, northern part of Fleming county, Ky."*

Dried soil of a light yellowish-umber color. A little shot iron ore was sifted out of it.

* A large proportion of this is water

No 979—Soil. *Labeled "Same Soil, from an adjoining field, in corn. Farm of Mr. Fitzgerald, northern part of Fleming county, Ky."*

Dried soil a little lighter colored and more yellowish than the preceding. A little shot iron ore was sifted out of it.

No. 980—Soil. *Labeled "Sub-soil from the same field. Mr. Fitzgerald's farm, northern part of Fleming county, Ky., &c., &c."*

Dried soil of a dirty-buff color. Contains a little shot iron ore, which was sifted out before analysis.

One thousand grains of each of these three soils, air-dried, were digested for a month in water charged with carbonic acid, and gave the following quantities of *soluble materials* severally, viz:

	No. 978. Virgin soil.	No. 979. Old field.	No. 980. Sub-soil.
Organic and volatile matters	0.950	0.566	0.366
Alumina, and oxides of iron and manganese and phosphates	.231	.187	.134
Carbonate of lime	2.563	1.573	1.130
Magnesia	.165	.061	.100
Sulphuric acid	.039	.033	.030
Potash	.109	.058	.032
Soda	.032	.028	.023
Silica	.281	.251	.264
Loss	.196	.093	----------
Soluble extract, dried at 400° F., (grains)	4.566	2.850	2.079

The *composition* of these three specimens of soil, dried at 400° F., is as follows:

	No. 978. Virgin soil.	No. 979. Old field.	No. 980. Sub-soil.
Organic and volatile matters	8.523	5.211	4.195
Alumina	6.840	5.275	6.265
Oxide of iron	5.760	5.510	6.035
Carbonate of lime	.870	.370	.395
Magnesia	.798	.736	.580
Brown oxide of manganese	.170	.270	.095
Phosphoric acid	.228	.409	.223
Sulphuric acid	.075	.093	.058
Potash	.526	.468	.700
Soda	.128	.043	.168
Sand and insoluble silicates	76.445	80.945	80.745
Loss	----------	.670	.541
Total	100.363	100.000	100.000
Moisture, lost at 400° F.	4.675	3.100	2.875

FRANKLIN COUNTY.

No. 981—Limestone. *Labeled "Building Stone; a bed in the Blue Limestone, in the northwest part of Franklin county, Ky. Said to be fire and frost proof."*

A brownish-grey, granular limestone; with many irregular pores, and small branching cavities, which are colored dirty-grey-brown; grains crystalline.

Dried at 212° it lost 0.200 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	93.580=52.511 per cent. of lime.
Carbonate of magnesia	3.663
Alumina, and oxides of iron and manganese	.880
Phosphoric acid	.117
Sulphuric acid	.441
Potash	.057
Soda	.165
Silex and insoluble silicates	.380
Loss	.717
	100.000

Quite a pure limestone.

No. 982—Soil. *Labeled "Virgin Soil, from the Blue-grass lands of Franklin county, Ky." Farm of Isaac Wingate. Primitive growth, large ash, burr oak, black locust, walnut, &c.*

Dried soil of a light chocolate color. Some chert and iron gravel were sifted out from it with the coarse seive.

No. 983—Soil. *Labeled "Soil from an old field, fifty to sixty years in cultivation. Blue-grass land of Franklin county, Ky. Farm of Isaac Wingate, &c."*

Dried soil of a light chocolate color, a slight shade *darker* than the preceding. Some iron gravel was sifted out of it.

No. 984—Soil. *Labeled "Sub-soil from the old field, &c. Blue-grass lands of Franklin county, Ky. Farm of Isaac Wingate," &c.*

Dried soil of a light chocolate color, a slight shade darker than the preceding.

One thousand grains of each of these soils, air-dried, were digested for a month in water charged with carbonic acid, to which they gave *soluble extracts* of the following *composition* and quantities:

	No. 982. Virgin soil.	No. 983. Old field.	No. 984. Sub-soil.
Organic and volatile matters	0.583	0.633	0.367
Alumina and oxides of iron and manganese and phosphates	.145	.230	.064
Carbonate of lime	.787	.1507	1.130
Magnesia	.123	.144	.113
Sulphuric acid	.041	.050	.033
Potash	.066	.077	.038
Soda	.017	.055	.012
Silica	.314	.200	.297
Soluble extract dried at 212° F., (grains)	2.076	2.896	2.054

Dried at 400° F., these soils had the following

COMPOSITION.

	No. 982. Virgin soil.	No. 983. Old field.	No. 984. Sub-soil.
Organic and volatile matters	6.372	6.147	4.281
Alumina	4.185	5.435	5.035
Oxide of iron	4.310	4.560	4.785
Carbonate of lime	.320	.320	.520
Magnesia	.563	.801	.526
Brown oxide of manganese	.320	.445	.095
Phosphoric acid	.350	.270	.553
Sulphuric acid	.076	.076	.050
Potash	.222	.288	.290
Soda	.052	.058	.073
Sand and insoluble silicates	82.270	81.470	83.445
Loss	.960	.130	.347
Total	100.000	100.000	100.000
Moisture, lost at 400° F.	2.700	2.400	2.125

With the exception of the phosphoric acid contained in it, the soil of the old field is yet as rich as the virgin soil; probably because of some admixture of the sub-soil with it by the use of the plow.

GARRARD COUNTY.

No. 985—LIMESTONE. *Labeled "Hydraulic? Limestone, Burdett's Knob, Garrard county, Ky. (Upper Silurian formation.")*

A greenish-grey, dull, fine granular limestone; not adhering to the tongue. Weathered surface brownish.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	34.780
Carbonate of magnesia	21.470
Alumina, and oxides of iron and manganese	5.200
Phosphoric acid	.310
Sulphuric acid	.956
Potash	.471
Soda	.130
Silex and insoluble silicates	35.180
Loss	1.503
	100.000

Although this contains a larger proportion of silica than the best water-limes, yet it is probable, that with proper management in its preparation, it will make a very good hydraulic cement.

No. 986—SOIL. *Labeled "Soil from woodland pasture, (pastured seven years,) from the farm of Chas. E. Spilman, on base-line* 178*th mile, one mile east of Dick's river, Garrard county, Ky."*

Dried soil of a greyish-light-chocolate color. Some shot ore and fragments of chert were sifted out of it with the coarse seive.

No. 987—SOIL. *Labeled "Sub-soil of the preceding,* (7 *to* 15 *inches deep.")*

Dried soil deeper and more brownish colored than the preceding. Some shot iron ore was sifted out of it with the coarse seive.

No. 988—SOIL. *Labeled "Soil from an old field fifty years or more in cultivation. Farm of Chas. J. Spilman, one mile east of Dick's river, Garrard county, &c."*

Lower Silurian formation; forty to fifty feet above the spring member of the sink country; near the top of the bird's-eye limestone. This field, after having been cultivated in grain of various kinds, was pastured for ten years; and is now in timothy and orchard grass.

Dried soil of a light-chocolate color. Some shot iron ore and small cherty fragments were sifted out of it.

No. 989—SOIL. *Labeled "Sub-soil, fifteen inches deep, mixed with all under a foot in depth; from the same place as the preceding, Garrard county, Ky., &c."*

Dried soil of a greyish-buff color. Some little shot iron ore was sifted out of it with the coarse seive.

These soils were collected by S. S. Lyon, Topographical Assistant.

One thousand grains of each of these soils, air-dried, were digested, for a month, in water charged with carbonic acid. The quantities and *composition* of the *soluble extract* dissolved out of them are as follows, viz:

	No. 986. Woodland soil.	No. 987. Sub-soil.	No. 988. Old field.	No. 989. Sub-soil.
Organic and volatile matters	0.533	0.366	0.483	0.273
Alumina, and oxides of iron and manganese and phosphates	.081	.063	.080	.088
Carbonate of lime	.263	.080	1.330	1.185
Magnesia	.073	.089		.093
Sulphuric acid	.022	.022	.310	.022
Potash	.102	.146		.054
Soda	.038	.037		.078
Silica	.232	.181	.180	.181
Loss	.056	.149	----------	----------
Soluble extract, dried at 212°, (grains)	1.400	1.133	2.383	1.974

The *composition* of these four soils, dried at 400° F., may be stated as follows:

	No. 986. Woodland.	No. 987. Sub-soil.	No. 988. Old field.	No. 989. Sub-soil.
Organic and volatile matters	4.200	2.988	5.294	3.411
Alumina	3.790	4.840	5.090	& ox. man.
Oxide of iron	3.310	3.970	3.910	13.635
Carbonate of lime	.170	.120	.110	2.470
Magnesia	.506	.540	.973	.325
Brown oxide of manganese	.295	.245	.245	----------
Phosphoric acid	.243	.260	.244	.249
Sulphuric acid	.096	.024	.050	.059
Potash	.135	.237	.190	.347
Soda	.032	.026	.026	.092
Sand and insoluble silicates	87.670	86.645	82.945	79.960
Loss	----------	.105	.923	----------
Total	100.447	100.000	100.000	100.548
Moisture, lost at 400° F.	2.400	2 460	2.725	2.525

GRANT COUNTY.

No. 990—MARL. *Labeled "Marl, alternating with Blue Limestone; in the Milk-sick region, at Moses Theobald's, Grant county, Ky."*

A greenish-grey, friable, marly clay.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	4.980
Carbonate of magnesia	3.285
Alumina and oxides of iron and manganese	16.250
Phosphoric acid	.310
Sulphuric acid	1.197
Potash	.988
Soda	.178
Sand and insoluble silicates	71.280
Water and loss	1.532
	100.000

The air-dried marl lost 1.00 per cent. of *moisture* at 212° F. Containing considerable proportions of potash, carbonate of lime, magnesia, and sulphuric and phosphoric acids, it would be a useful top-dressing to exhausted land.

No. 991—SHALE. *Labeled "Shale from the Milk-sick region, Moses Theobald's, Grant county, Ky. Lower Silurian."*

A greenish-grey and buff-grey, soft shale, or indurated clay. Dried at 212° F., it lost 1.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	78.490
Alumina and oxides of iron and manganese	12.340
Carbonate of lime	2.780
Magnesia	1.491
Phosphoric acid	.630
Sulphuric acid	.338
Potash	.957
Soda	trace.
Water and loss	3.074
	100.000

Contains also a considerable quantity of potash.

GRAYSON COUNTY.

No. 992—LIMESTONE. *Labeled "Coralline Limestone, Falls of Rough Creek, Grayson county, Ky. Upper member of sub-carboniferous limestone."*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	85.680
Carbonate of magnesia	2.503
Alumina and oxides of iron and manganese	2.560
Phosphoric acid	.182
Sulphuric acid	.839
Potash	.359
Soda	trace.
Silex and insoluble silicates	7.480
Loss	.397
	100.000

GREENUP COUNTY.

No. 993—Limonite. *Labeled "Blue Limestone Ore, Kenton Furnace, Greenup county, Ky. Said to have yielded well. Ore used without roasting. Is the light-colored, in the center of the ore, as rich as the outside?"*

Exterior portion dull yellowish-brown, fine-granular; adhering strongly to the tongue; separates easily from the interior light-grey portion. (See next number.) Powder yellowish-brown. Dried at 212° F., it lost 1.60 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	46.640	=32.663 per cent. of iron.
Alumina	2.440	
Carbonate of lime	.380	
Magnesia	1.902	
Brown oxide of manganese	1.380	
Phosphoric acid	.412	
Sulphuric acid	.255	
Potash	.656	
Soda	.192	
Silex and insoluble silicates	36.240	
Combined water	9.300	
Loss	.203	
	100.000	

No. 994—Carbonate of Iron. *Labeled "Interior grey portion of the Blue Limestone Ore, Kenton Furnace, Greenup county, Ky."*

Dull, fine-granular; adheres slightly to the tongue. Powder of a light grey color. Specific gravity 2.9851.

Dried at 212° F., it lost 0.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	41.260	=22.788 per cent. of iron.
Oxide of iron	4.760	
Carbonate of lime	1.880	
Carbonate of magnesia	5.981	
Carbonate of manganese	2.980	
Alumina	1.580	
Phosphoric acid	.374	
Sulphuric acid	.290	
Potash	.579	
Soda	.150	
Silex and insoluble silicates	40.080	
Loss	.086	
	100.000	

These analyses illustrate the changes of composition which occur during the gradual convertion of *carbonate* of iron into limonite (hydrated peroxide of iron) ore.

No. 995—CARBONATE OF IRON. *Labeled "Limestone Ore, Kenton Furnace, Greenup county, Ky."*

A dull, dark grey, fine-granular ore. Adheres to the tongue. Exterior surface brownish-yellow and reddish. Specific gravity 3.2750.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	56.267	=29.024 per cent. of iron.
Oxide of iron	3.882	
Alumina	5.980	
Carbonate of lime	4.980	
Carbonate of magnesia	3.626	
Carbonate of manganese	.873	
Phosphoric acid	2.029	
Sulphuric acid	.750	
Potash	.347	
Soda	.186	
Silex and insoluble silicates	20.640	
Loss	.440	
	100.000	

Although this ore is not too poor to be employed alone for the production of iron, it is objectionable, because of the large proportion of phosphoric acid which it contains; which would injure the quality of the iron produced, by making it brittle or cold-short.

The composition of the following limonite ores, of Kenton furnace, will be presented in a tabular form.

No. 996—LIMONITE. *Labeled "Block Ore, three feet above the 'Little Block,' bed six inches thick, Kenton Furnace, Greenup county, Ky."*

Irregular thin layers of dark-brown fine-granular limonite, inclosing yellow and brownish-yellow ochreous ore. Powder brownish-yellow.

No. 997—LIMONITE. *Labeled "Ore associated with sub-carboniferous limestone, Kenton Furnace, &c."*

A pretty dense, dark-brown ore, in irregular curved layers, with irregular cavities between; adheres very slightly to the tongue. Contains very little soft ochreous ore. Powder yellowish-brown.

No. 998—LIMONITE. *Labeled "John Conley Ore, imperfectly roasted, Kenton Furnace, &c."*

A dull, nearly black, ore; adheres strongly to the tongue. Powder nearly black.

No. 999—LIMONITE. *Labeled "Rough Big Block Ore, now rejected at Kenton Furnace, &c. Near the top of millstone grit. Specimen above average."*

Dark-brown, dense, irregular curved thick layers; sparkling with small specks of mica and crystalline facets; not adhering to the tongue; incrusted with reddish and whitish soft material. Powder yellowish-brown.

No. 1000—LIMONITE. *Labeled "Little Block Ore, five inches thick, bedded between clays, of which the lowest bed is white, Kenton Furnace, &c."*

A dull, fine-granular, porous ore; adhering strongly to the tongue; formed of irregular curved layers, of a dark-yellowish-brown color, involving yellow and brownish-yellow soft ochreous material. A few minute specks evident, and, in some places, a fine-grained oolitic appearance. Powder brownish-yellow.

No. 1001—LIMONITE. *Labeled "Marl Ore, from the bed of pink ferruginous clay, Kenton Furnace, &c."*

Dull, dark greyish purple, oolitic; composed of dark colored grains mingled with whitish ones. Adheres to the tongue. Powder greyish dull-red.

No. 1002—LIMONITE. *Labeled "Flat Kidney Ore, Kenton Furnace, &c."*

Dull, fine granular, purplish-brown, with grains of darker and lighter-color mixed, and a brownish-yellow incrustation. Adheres to the tongue. Powder dull red, or spanish brown color.

No. 1003—IMPURE LIMONITE. *Labeled "Near the Pink Clay Ore, Kenton Furnace, &c."*

Compact, brittle, fracture uneven; dense; general color, dark olive-grey, approaching umber; exterior and in the fissures iron-rust brown. Does not adhere to the tongue. Specific gravity 2.772. Powder yellowish-grey.

No. 1004—LIMONITE. *Labeled "Dogstone Ore, Kenton Furnace, &c."*

Dull, dark purplish and reddish-brown, nearly black; very fine granular with small irregular pores. Adheres strongly to the tongue. Powder dark-brown, nearly black.

No. 1005—LIMONITE. *Labeled "Ferruginous Fossiliferous Knob-stone, near Kenton Furnace, Greenup county, Ky."*

Dull, with a few minute scales of mica; containing numerous impressions of bi-valve shells. General color brownish-yellow, with darker and lighter shades; adheres strongly to the tongue.

COMPOSITION OF THESE TEN LIMONITES, DRIED AT 212° F.

	No. 996.	No. 997.	No. 998.	No. 999.	No. 1000	No. 1001	No. 1002	No. 1003	No. 1004	No. 1005
Oxide of iron.....	33.540	78.840	82.240	44.980	51.400	49.740	59.680	21.740	83.880	46.540
Alumina.........	4.887	.980	.580	2.580	3.720	3.000	5.120	19.160	.280	3.148
Lime.............	trace.	trace.	trace.	trace.	trace.	trace.	trace.	trace.	trace.	trace.
Magnesia.........	1.635	.471	1.041	.894	1.343	.603	.763	.628	.543	.919
Brown oxide of manganese.....	.280	2.204	5.984	.080	.880	.480	1.060	.080	5.380	1.080
Phosphoric acid..	.733	.541	.310	.694	2.462	1.742	2.037	trace.	.822	1.232
Sulphuric acid...	.290	.166	.969	.372	.396	.269	.303	.990	.236	.303
Potash...........	.502	.127	.224	.135	.440	.166	.251	.165	.252	.618
Soda.............	.265	.319	.093	.260	trace.	,179	.264	.119	trace.	.015
Silex & insoluble silicates........	49.480	3.960	1.920	41.680	28.520	35.180	23.560	47.480	1.680	37.320
Combined water.	8.860	11.960	7.340	8.400	10.600	8.600	7.160	10.300	7.760	9.340
Loss.............	....	.352	....	....	.249	.041	....	....	....	....
Total.........	100.472	100.000	100.001	100.075	100.000	100.000	100.218	100.662	100.833	100.515
Percentage of iron	23.488	55.213	57.595	31.500	35.996	26.594	33.000	15.225	58.742	30.396
Moisture lost at 212 deg. F.......	2.140	1.100	1.260	1.200	2.340	2.800	2.760	2.300	2.140	1.600

There is considerable variety of composition amongst these ores. Nos. 1000, 1001, 1002, and 1005 contain a large amount of phosphoric acid; and No. 1003 has a considerable quantity of sulphuric acid. This latter, indeed, is too poor to be used for itself as an ore. They all are destitute of any notable quantity of lime.

A specimen labeled "*From Kenton Furnace, per Basil Waring, examined for manganese,*" is a porous limonite, not containing an extraordinary quantity of manganese. (See Vol. I, page 197, and Vol. II, page 204, of these Reports, for other notices of Kenton furnace ores.)

No. 1006—FERRUGINOUS CLAYSTONE. *Labeled "Clay Iron Stone, Kenton Furnace, Greenup county, Ky."* (*Is it workable?*)

A dull pink, in some parts grey, indurated clay; too hard to be scratched with the nail; containing very small cavities or pores, some of which are filled with infiltrated spar. Exterior weathered surface of a brownish-yellow color. Adheres strongly to the tongue. Powder of a pink color.

No. 1007—FERRUGINOUS CLAYSTONE. *Labeled "Clay Iron Stone, Kenton Furnace, &c. Variety (a). How much iron?"*

Harder and more compact than the last; does not adhere much to the tongue. Color, dirty-salmon. Weathered surface, brown; when burnt, of a cinnamon color.

No. 1008—FERRUGINOUS CLAYSTONE. *Labeled "Variety (b,) Kenton Furnace, &c."*

Dull, of a light yellow ochre color; adheres strongly to the tongue; not scratched by the nail. Powder of a light salmon color, deepened a little by burning.

COMPOSITION OF THESE THREE FERRUGINOUS CLAYSTONES.

	No. 1006.	No. 1007.	No. 1008.
Silica	44.020	42.920	43.780
Alumina	32.810	37.440	41.000
Oxides of iron and manganese	7.880	4.940	
Lime	a trace.	a trace.	a trace.
Magnesia	.373	.245	.281
Phosphoric acid	.310	.207	.246
Potash	.146	.135	.193
Soda	1.121	.205	.856
Combined water	13.360	13.700	13.360
Loss	----------	.208	.284
Total	100.020	100.000	100.000
Moisture, lost at 212° F.	1.300	1.700	0.400

These are strikingly alike in composition, and of no value as iron ores.

No. 1009—LIMESTONE. *Labeled "Limestone used as a flux at Kenton Furnace, Greenup county, Ky. (Sub-carboniferous.")*

A dense, very fine-grained, light-grey limestone; traversed by small veins of calc. spar. Specific gravity 2.7065.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	94.980	=53.298 per cent. of lime.
Carbonate of magnesia	1.583	
Alumina, and oxides of iron and manganese	.580	
Phosphoric acid	a trace.	
Sulphuric acid	.317	
Potash	.212	
Soda	.140	
Silex and insoluble silicates	2.080	
Loss	.108	
	100.000	

Quite a pure limestone, well suited to the purpose for which it is used.

No. 1010—Pig Iron. *Labeled "Soft Iron from Kenton Furnace. Furnace making grey slag and producing much carburet of iron."*

A moderately coarse-grained, light-grey, iron. Yields easily to the file. Fragments flatten considerably under the hammer, but soon break to pieces.

No. 1011—Pig Iron. *Labeled "Hard Iron, Kenton Furnace. Made when producing green slag, and when the furnace is supposed not to be hot enough. Furnace will not make as much as when producing grey iron."*

A fine-grained, light colored iron; too hard to be acted on by the file.

COMPOSITION OF THESE TWO SAMPLES OF IRON.

	No. 1010. Soft grey iron.	No. 1011. Hard whitish iron.
Iron	94.162	94.057
Graphite	2.120	1.556
Combined carbon	.180	.914
Manganese	.078	.345
Silicon	1.085	.507
Slag	.284	.284
Aluminum	.255	.149
Calcium	----------	trace.
Magnesium	.675	.179
Potassium	.112	.640
Sodium	.049	.109
Phosphorus	1.050	.823
Sulphur	.232	.259
Loss	----------	.178
Total	100.282	100.000
Total carbon	2.300	2.470
Specific gravity	6.8613	----------

The *slags* which accompanied these specimens of iron not having been sent for analysis, it is not possible to say *positively* why the hard white iron was produced; but the probability is that some irregularity had occurred in the quantity of flux used, and that the limestone was in smaller proportion than usual. The *green* slag always contains a considerable amount of iron in the form of protoxide, and hence the reduction in the amount of iron turned out.

No. 1012—IMPURE CARBONATE OF IRON. *Labeled "Lowest Ore of Greenup county, Ky., north of Little Sandy river, a few feet above the Knob-stone. The sub-carboniferous limestone and millstone grit both absent. The coal measures resting on the Knob-stone." How much iron?*

A dark-grey, dense, fine granular ore; containing a few minute scales of mica. Exterior weathered surface dark brown. Powder dark drab-grey color.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	50.936	=24.609 per cent. of iron.
Alumina	2.200	
Carbonate of lime	1.980	
Carbonate of magnesia and loss	4.365	
Carbonate of manganese	1.445	
Phosphoric acid	.482	
Sulphuric acid	.612	
Potash	not estimated.	
Soda	not estimated.	
Silex and insoluble silicates	37.980	
	100.000	

No. 1013—FERRUGINOUS LIMESTONE. *Labeled "Iron Ore, No.* 11, *from Steam Furnace, Greenup county, Ky."*

A compact, fine-grained grey limestone; with a few small shining facets on the fractured surface. Not adhering to the tongue. Weathered surface reddish-brown. Powder of a light-grey color. Specific gravity 2.8358.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	65.280
Carbonate of iron	28.841
Carbonate of magnesia	4.346
Brown oxide of manganese	.380
Alumina	.280
Phosphoric acid	a trace.
Sulphuric acid	1.196
Potash	.027
Soda	.191
Silex and insoluble silicates	.380
	100.921

Dried at 212° F., it lost 0.300 per cent. of *moisture.*

A specimen labeled "*Looped Ore, rejected when thus roasted, at Steam Furnace,*" *&c.*, is of a dark color, almost black; having a somewhat glistening appearance on the fractured surfaces, and, although somewhat cellular, does not adhere to the tongue. It has been heated too much, or too suddenly, in roasting; so that it has undergone partial fusion, and

has lost its porosity. Hence it is smelted with difficulty, because the combustible gases cannot easily penetrate it to cause the reduction of the oxide of iron and the carbonation of the iron, &c.

No. 1014—Carbonate of Iron. *Labeled "Ore, (No. 1,) from Drift bank, side of hill, Caroline Furnace, Greenup county, Ky. Rejected at the Furnace."*

Fine-granular, of a dark grey-drab color, with mottlings of lighter colored, and darker horizontal lines of deposition. Weathered surface, to the depth of one third of an inch, of a bright reddish-brown color. General appearance dull when viewed perpendicularly, but by reflected light exhibiting glistening, apparently crystalline surfaces, even in the weathered portion, like sparry iron or some kinds of *blende*. Adheres slightly to the tongue. Powder brownish-grey. An average portion taken for analysis. Specific gravity 3.4463.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	67.624	=36.234 per cent. of iron.
Oxide of iron	5.086	
Alumina	.780	
Carbonate of lime	17.680	
Carbonate of magnesia	4.933	
Carbonate of manganese	1.650	
Phosphoric acid	1.053	
Sulphuric acid	.990	
Potash	.380	
Soda	.202	
Silex and insoluble silicates	.520	
	100.558	

This ore contains so little alumina and silex, that it could not be smelted in the usual way, by the addition of limestone alone; but, mixed with silicious and aluminous ores, or even with ferruginous clay, or good common clay, it would smelt very well. It contains, however, considerable proportions of phosphoric and sulphuric acids, which would tend to injure the quality of the iron made from it. A portion of these might be removed, however, by the use of much pure clay and limestone in the flux.

No. 1015—Iron Furnace Slag. *Labeled "Green Slag, with ore involved, Clinton Furnace, Greenup county, Ky."* (*See Vols. I and II of these Reports for Clinton Furnace ores, &c., &c.*)

A glassy, bottle-green slag, involving some particles of iron; transparent in thin fragments. Very fusible before the blow-pipe, melting without intumescence.

COMPOSITION.

Silica	52.580	Containing oxygen=27.301
Alumina	11.280	5.272
Lime	16.905	4.806
Magnesia	2.141	.855
Protoxide of iron	10.783	2.393
Protoxide of manganese	2.121	.476
Phosphoric acid	a trace.	
Potash	3.121	.527
Soda	.265	.068
Loss	.804	
	100.000	

The oxygen in the *bases* is to that in the silica, as 14.397 is to 27.301
or as 1. is to 1.896

Too small a quantity of lime in the flux caused the loss of much iron, in the form of protoxide of iron, in the slag; which gave it the bottle-green color, and increased its fusibility. When the cinder is very dark colored and fluid from this cause, the furnace is said to "scour."

No. 1016—CARBONATE OF IRON. *Labeled "Rejected Ore, Bellefonte Furnace, Greenup county, Ky."* *Obtained by S. S. Lyon, Esq.*

A dark-grey carbonate; not adhering to the tongue; under the lens appears to be made up of dark grains with a lighter colored cement; some whitish substance infiltrated in the fissures. Weathered surfaces brownish. Powder brownish-grey.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	81.448	=40.646 per cent. of iron.
Oxide of iron	1.493	
Alumina	.240	
Carbonate of lime	2.580	
Carbonate of magnesia	2.581	
Carbonate of manganese	1.926	
Phosphoric acid	.374	
Sulphuric acid	1.197	
Potash	.366	
Soda	.011	
Silex and insoluble silicates	7.924	
	100.140	

Dried at 212° F., it lost 0.60 per cent. of *moisture.*

The only objectionable feature in the composition of this ore is the considerable proportion of sulphuric acid; otherwise it is good and quite rich ore. By careful roasting, the use of much lime for flux, and mixture with other ores which contain more alumina and silica, or with pure clay or earth, it may be used with advantage.

No. 1017—LIMONITE. *Labeled "Rejected Ore, at Bellefonte Furnace, Greenup county, Ky."* (*Obtained by S. S. Lyon, Esq.*)

A dark-brown limonite, in curved irregular layers, involving small

cavities; incrusted with brownish-yellow, soft ochreous ore. Powder of a light yellowish-brown color.

Dried at 212° F., it lost 1.00 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	74.740	=52.342 per cent. of iron.
Alumina	.980	
Carbonate of lime	a trace.	
Carbonate of magnesia	1.180	
Carbonate of manganese	1.629	
Phosphoric acid	.758	
Sulphuric acid	.544	
Potash	.243	
Soda	.114	
Silex and insoluble silicates	6.984	
Combined water and loss	12.828	
	100.000	

Quite a rich ore. Rejected, probably, because it does not contain enough earthy materials to form "*cinder*," to protect the reduced iron in the furnace. By mixture with poorer aluminous ores, or by the addition of ferruginous clay, or even common pure clay, or earth, or shale, and a sufficient amount of limestone, it may be smelted without difficulty.

No. 1018—CARBONATE OF IRON. *Labeled "Company Bank, (No. 500,) Raccoon Furnace, Greenup county, Ky." (Obtained by the late Mr. Mylott.)*

Interior portion, (see next number for the *exterior portion,*) grey, granular, with some glimmering scales of mica. Under the lens appears to be made up of brownish grains, mixed with a lighter colored material. Powder grey. Specific gravity 3.1778.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	17.763	=23.488 per cent. of iron.
Oxide of iron	21.286	
Alumina	.680	
Carbonate of lime	37.580	
Carbonate of magnesia	2.901	
Carbonate of manganese	1.475	
Phosphoric acid	.310	
Sulphuric acid	1.470	
Potash	.270	
Soda	.166	
Silex and insoluble silicates	8.440	
Combined water and loss	7.659	
	100.000	

A poor ore, which contains enough lime for its own flux. The *exterior* portion is richer.

No. 1019—LIMONITE. *Labeled "Exterior portion of Company Bank Ore, Raccoon Furnace, Greenup county, Ky." (Obtained by the late Mr. Mylott.)*

Of a dark-brown color; made up of minute dark-colored rounded grains, involved in a lighter colored cement. Powder of a rich yellowish-brown color. Dried at 212° F., it lost 1.60 per cent. of *moisture*.

COMPOSITION, DRIED AT 212° F.

Oxide of iron	43.280	=30.309 per cent. of iron.
Alumina	1.580	
Carbonate of lime	33.180	
Carbonate of magnesia	2.337	
Brown oxide of manganese	1.180	
Phosphoric acid	.508	
Sulphuric acid	.338	
Potash	.374	
Soda	.120	
Silex and insoluble silicates	13.184	
Combined water and loss	3.919	
	100.000	

This ore contains enough lime for its own flux, but not enough earthy material. It would be best smelted in mixture with more aluminous and silicious ores.

No. 1020—IMPURE LIMONITE. *Labeled "Ferruginous Conglomerate, seventy-five feet above Company Bank, on the hill north of Raccoon Furnace. Highest measures seen here; equivalent to the limestone ore horizon." (Obtained by S. S. Lyon, Esq.)*

A dark-brown, compact limonite, involving rounded pebbles of milky quartz, and quartz sand. Powder of a rich yellowish-brown color.

Dried at 212° F., it lost 0.80 per cent. of *moisture*.

COMPOSITION, DRIED AT 212° F.

Oxide of iron	45.070	=31.563 per cent. of iron.
Alumina	.730	
Carbonate of lime	trace.	
Magnesia	.808	
Brown oxide of manganese	.355	
Phosphoric acid	1.056	
Sulphuric acid	.165	
Potash	.337	
Soda	.114	
Silex and insoluble silicates	44.720	
Combined water	7.800	
	101.155	

This ore contains much silex and very little, if any, lime. It might be smelted in mixture with the preceding and some more aluminous ore. It is quite rich enough in iron; but contains its silex mainly in the form of pebbles, and has a considerable percentage of *phosphoric acid*.

No. 1021—COAL. *Labeled "Cannel Coal, sent by Col. L. G. Bradford, of Augusta; obtained from a bed about four feet ten inches thick, on the farm formerly owned by Levin Shreve, of Louisville; known as Fulton Forge; three miles above Greenupsburg, and one mile from the Ohio river, Greenup county, Ky."*

In large blocks; not soiling the fingers; cleaving in irregular layers with no fibrous coal between them; of a jet black color. A small portion more slatey, with pyritous impressions of vegetable remains. Over the spirit-lamp it softened and agglutinated somewhat; but did not swell much. Specific gravity 1.271.

PROXIMATE ANALYSIS.

Moisture	4.70	Total volatile matters	44.90
Volatile combustible matters	40.20		
Fixed carbon in the coke	52.40	Dense coke	55.10
White ashes	2.70		
	100.00		100.00

The percentage of *sulphur* is 0.837.

Submitted to destructive d stillation, in an iron retort, at a heat gradually raised to dull redness, tl e following products were obtained in three several experiments:

	First trial.	Second trial.	Third trial.
Crude oil, (dark and thick)	209.	200.	189.
Black ammoniacal water	78.	99.	111.
Coke	543.	548.	555.
Combustible gas, and loss	170.	153.	145.
	1000.	1000.	1000.

The gases collected in each experiment, varied in quantity from seven hundred and ten to seven hundred and sixty cubic inches in volume, from the thousand grains; and possessed good illuminating power.

This is a good pure cannel coal, which would answer well for domestic purposes, and for the production of steam on steamboats, &c. The specimens tried fall below the Breckinridge and Haddock's cannel coals in the proportion of coal oil.

No. 1022—LIMONITE. *Labeled "Best Chocolate, or Red Ore, Pennsylvania Furnace, new bank: tail six inches, thickening to four feet and upward; Greenup county, Ky."*

A deep brownish-red ore; mottled with lighter orange red; adhering to the tongue. Specific gravity 3.153.

Dried at 212° F., it lost 1.40 per cent. of *moisture*.

COMPOSITION, DRIED AT 212° F.

Oxide of iron	61.640	=43.167 per cent. of iron
Alumina	1.200	
Carbonate of lime	14.380	
Magnesia	1.818	
Brown oxide of manganese	.380	
Phosphoric acid	1.591	
Sulphuric acid	.067	
Potash	.324	
Soda	.205	
Silex and insoluble silicates	10.800	
Combined water	7.640	
	100.045	

Quite a rich ore; which contains a considerable proportion of lime. It should be mixed with more aluminous ores, or earthy material, to furnish "*cinder*," and to aid in getting rid of some of its *phosphoric acid.*

HANCOCK COUNTY.

No. 1023—IMPURE LIMONITE. *Labeled "Ferruginous Conglomerate, associated with the Lewisport coal, Hancock county, Ky."* (*Sent by S. S. Lyon, Esq.*)

A portion of the mass uniform in structure, fine-granular, dark-grey, with brownish weathered surfaces; the other portion a conglomerate of irregular ferruginous pebbles, generally rounded, of a dull reddish-brown color; containing fibrous coal and small scales of mica. Powder yellowish-brown.

Dried at 212° F., it lost 1.15 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	33.640	=23.658 per cent. of iron.
Alumina	2.980	
Carbonate of lime	.580	
Carbonate of magnesia	10.693	
Brown oxide of manganese	.784	
Phosphoric acid	.374	
Sulphuric acid	.612	
Potash	.424	
Soda	.249	
Silex and insoluble silicates	44.180	
Combined water and loss	5.484	
	100.000	

Rather too poor to be profitably smelted for iron.

No. 1024—CARBONATE OF IRON. *Labeled "Carbonate of Iron, associated with the Lewisport coal, Hancock county, Ky."* (*Obtained by S S. Lyon, Esq.*)

A dense, fine-grained dark-grey ore. Large conchoidal fracture.

Weathered surfaces yellowish and reddish-brown. Powder, buff-grey. Specific gravity 3.5482.

Dried at 212° F., it lost 0.550 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	73.626	=39.596 per cent. of iron.
Oxide of iron	5.752	
Alumina	1.460	
Carbonate of lime	1.380	
Carbonate of magnesia	7.020	
Carbonate of manganese	.584	
Phosphoric acid	.694	
Sulphuric acid	.248	
Potash	.201	
Soda	.172	
Silex and insoluble silicates	9.080	
	100.217	

No. 1025—SOIL. *Labeled "Soil, (for eighteen inches in depth,) under the Lewisport coal; in the Ohio Bottom, above overflow, Pell and Brother's land, Hancock county, Ky."* (*Obtained by S. S. Lyon, Esq.*)

Dried soil of a light-umber color.

No. 1026—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil of a dirty-buff color.

One thousand grains of each of these soils, digested for about a month in water charged with carbonic acid gas, gave to it the following *soluble materials*, viz:

	No. 1025. Soil.	No. 1026. Sub-soil.
Organic and volatile matters	1.333	0.323
Alumina, and oxides of iron and manganese and phosphates	.730	.115
Carbonate of lime	.963	.063
Magnesia	.161	.094
Sulphuric acid	.039	.039
Potash	.127	.120
Soda	.296	.372
Silica	.214	.154
Loss	.454	.310
Soluble extract from 1000 grains of the air-dried soil	4.317	1.590

Dried at 400° F., the air-dried soils lost of *moisture*, as follows: the *soil* lost 1.30 per cent. and the *sub-soil* lost 0.923 per cent. Their *composition* thus dried, is as follows:

	No. 1025. Soil.	No. 1026. Sub-soil.
Organic and volatile matters	3.865	2.019
Alumina	3.465	3.390
Oxide of iron	1.970	2.690
Carbonate of lime	.170	.021
Magnesia	.393	.439
Brown oxide of manganese	.233	.095
Phosphoric acid	.143	.190
Sulphuric acid	.042	.042
Potash	.150	.181
Soda	.100	.057
Sand and insoluble silicates	90.520	90.720
Loss	----------	.156
Total	101.051	100.000

No. 1027—Soil. *Labeled "Soil, forty-five feet above the Lewisport Coal. From an old field on Bush and Williams' land, Hancock county, Ky." (Obtained by S. S. Lyon, Esq.)*

Dried soil of a light, yellowish-umber color.

No. 1028—Soil. *Labeled "Sub-soil of the preceding; (eighteen inches deep,) &c., &c."*

Dried sub-soil of a brownish-buff color.

One thousand grains of each of these soils, air-dried, were digested for about a month in water charged with carbonic acid gas, to which they gave up *soluble extract*, as follows, dried at 212° F.:

	No. 1027. Soil.	No. 1028. Sub-soil.
Organic and volatile matters	1.250	0.377
Alumina, and oxides of iron and manganese and phosphates	1.663	.117
Carbonate of lime	2.713	.070
Magnesia	.166	.190
Sulphuric acid	.070	.045
Potash	.190	.046
Soda	.183	.084
Silica	.200	.267
Loss	.317	----------
Soluble extract from 1000 grains of air-dried soil, (grains)	6.752	1.196

The *composition* of these soils, dried at 400° F., is as follows:

	No. 1027. Soil.	No. 1028. Sub-soil.
Organic and volatile matters	6.071	4.129
Alumina	3.465	5.440
Oxide of iron	3.710	5.725
Carbonate of lime	.346	.246
Magnesia	.544	.797
Brown oxide of manganese	.095	.170
Phosphoric acid	.187	.145
Sulphuric acid	.050	.047
Potash	.367	.391
Soda	.077	.349
Sand and insoluble silicates	84.945	82.745
Loss	.143	----------
Total	100.000	100.184
Moisture, lost at 400° F.	2.400	2.525

No. 1029—SOIL. *Labeled "Soil, top of hill, woods; farm of George Smith, Esq., waters of Blackford creek; two and a half miles in the rear of Lewisport, Hancock county, Ky." (Obtained by S. S. Lyon, Esq.) On the coal measures, above the Lewisport coal.*

Dried soil of a light, yellowish-umber color.

No. 1030—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil of a dirty-buff color.

The quantity and *composition* of the *soluble extract* given up by one thousand grains of these two soils, air-dried, and digested for about a month in water charged with carbonic acid, are as follows:

	No. 1029. Soil.	No. 1030. Sub-soil.
Organic and volatile matters	1.267	0.393
Alumina, and oxides of iron and manganese and phosphates	1.213	.213
Carbonate of lime	1.307	.207
Magnesia	.205	.017
Sulphuric acid	.045	.041
Potash	.059	.034
Soda	.109	.054
Silica	.200	.200
Loss	.346	----------
Soluble extract, from 1000 grains of air-dried soil, (grains)	4.751	1.159

The *composition* of these two soils, dried at 400° F., is as follows:

	No. 1029. Soil.	No. 1030. Sub-soil.
Organic and volatile matters	4.422	3.678
Alumina	3.215	4.890
Oxide of iron	3.285	5.135
Carbonate of lime	.171	.071
Magnesia	.446	.799
Brown oxide of manganese	.241	.120
Phosphoric acid	.161	.152
Sulphuric acid	.059	.016
Potash	.205	.328
Soda	.040	.051
Sand and insoluble silicates	88.130	84.720
Loss	---------	.040
	100.375	100.000
Moisture, lost a 400°, (per cent.)	2.200	2.125

Mem.—Nos. 1031 and 1032, accidentally omitted, will be found under the head of Owsley and Powell counties.

No. 1033—Soil. *Labeled "Soil from Mr. Greathouse's farm, one hundred feet above Hawes'. Thin soil, soon tired, Hancock county, Ky." (Obtained by S. S. Lyon, Esq.)*

Dried soil of a dark umber-grey color.

No. 1034—Soil. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil of a rich brownish-orange color.

One thousand grains of each of these two soils, air-dried, digested for a month in water charged with carbonic acid, gave up as follows:

	No. 1033. Soil.	No. 1034. Sub-soil.
Organic and volatile matters	0.767	0.850
Alumina, and oxides of iron and manganese and phosphates	.196	.063
Carbonate of lime	1.230	.230
Magnesia	.116	.129
Sulphuric acid	.024	.037
Potash	.182	.064
Soda	.149	.114
Silica	.281	.147
Loss	.305	.166
Total *soluble extract*, dried at 212° F., (grains)	3.250	1.800

The *composition* of these two soils, dried at 400° F., is as follows:

	No. 1033. Soil.	No. 1034. Sub-soil.
Organic and volatile matters	4.729	3.642
Alumina	2.115	5.390
Oxide of iron	1.900	6.400
Carbonate of lime	.196	.071
Magnesia	.408	.585
Brown oxide of manganese	.070	.095
Phosphoric acid	.185	.151
Sulphuric acid	.042	not estim'd
Potash	.212	.413
Soda	.062	.131
Sand and insoluble silicates	91.170	83.320
	101.089	100.198
Moisture, lost at 400° F.	1.475	1.850

No. 1035—COAL. *Labeled "Upper part of Mayo's Coal, Hawesville, Hancock county, Ky."*

A dull, pitch-black, cannel coal; with a large conchoidal fracture. Over the spirit lamp does not soften nor alter its form. Specific gravity 1.359.

PROXIMATE ANALYSIS.

Moisture	4.30	Total volatile matters	41.50
Volatile combustible matters	37.20		
Fixed carbon in the coke	42.60	Dense coke	58.50
Buff-grey ashes	15.90		
	100.00		100.00

The proportion of *sulphur* is 1.306 per cent.

COMPOSITION OF THE ASHES.

Silica	9.980
Alumina, and oxides of iron and manganese and trace of phosphates	5.180
Lime	trace.
Magnesia	.166
Sulphuric acid	.063
Potash	.347
Soda	.186
	15 922

The large percentage of ash in this specimen of coal detracts from its value.

No. 1036—COAL. *Labeled "Boyd's Coal, Hawesville, Hancock county, Ky."*

A pretty firm, shining, dark pitch-black coal; cleaving generally with shining irregular surfaces. A little granular pyrites on some of the lay-

ers. Over the spirit lamp it softened and agglutinated; swelling up into a spongy coke. Specific gravity 1.268.

PROXIMATE ANALYSIS.

Moisture	5.46	Total volatile matters	46.60
Volatile combustible matters	41.14		
Fixed carbon in the coke	48.80	Moderately light coke	53.40
Grey-purple ashes	4.60		
	100.00		100.00

The percentage of *sulphur* is 3.361.

COMPOSITION OF THE ASHES.

Silica	1.184
Alumina, and oxides of iron and manganese and trace of phosphates	3.080
Lime	a trace.
Magnesia	.067
Sulphuric acid	a trace.
Potash	.270
Soda	.038
	4.639

HARDIN COUNTY.

No. 1037—LIMESTONE. *Labeled "Lithographic? Stone, Sinking creek, Hardin county, Ky. Sub-carboniferous."*

Of a light buff-grey color. Fine granular; pretty uniform in structure; only a few specks of oxide of iron in places; and some signs of fossils on the weathered surfaces. Fracture large-conchoidal.

Dried at 212° F., its powder lost 0.30 per cent. of *moisture.*

No. 1038—LIMESTONE. *Labeled "Sub-carboniferous Limestone, four miles west of Big Spring, Hardin county, Ky."*

A fine-granular, dull, grey rock, with a few small glimmering facets of calc. spar.

Dried at 212° F., its powder lost 0.34 per cent. of *moisture.*

No. 1039—LIMESTONE. *Labeled "Oolitic Limestone. Sub-carboniferous. One and a half miles south of Big Spring, Hardin county, Ky. On the farm of Mr. Mooreman, about the level of the first red soil and sub-soil of the sub-carboniferous. The first bed under the millstone grit." (Sent by S. S. Lyon, Esq.)*

A dull, chalky-white rock, principally made up of very small, round, oolitic grains. Reddish on the exterior surface, where it is porous from the dropping out of the round grains.

Dried at 212° F., it lost 0.30 per cent. of moisture.

COMPOSITION OF THESE THREE LIMESTONES, DRIED AT 212° F.

	No. 1037. Lithographic?	No. 1038. Limestone.	No. 1039. Oolitic.
Carbonate of lime	79.180	82.280	98.580
Carbonate of magnesia	11.469	7.300	.629
Alumina, and oxides of iron and manganese	.880	.660	.460
Phosphoric acid	.156	.182	.125
Sulphuric acid	.338	.417	.274
Potash	.173	.386	.154
Soda	.098	.090	.022
Silex and insoluble silicates	6.980	9.220	.380
Loss	.726	----------	----------
	100.000	100.535	100.624

The "oolitic" is a remarkably *pure* limestone, and could be employed in all cases where a *pure white* lime is required. Whether No. 1037 would answer for a lithographic stone, will depend upon its freedom from pores and flaws, &c. It appears to be sufficiently fine in its grain, and of the proper composition.

No. 1040—SOIL. *Labeled " Virgin Soil, from woods; from the farm of Bernard Eskridge, head waters of Otter Creek, Hardin county, Ky." Growth, white oak, hickory, and sassafras.* (*Sub-carboniferous; below the cavernous members.*

The dried soil is of a light, greyish-umber color.

No. 1041—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

The dried sub-soil is much lighter colored than the preceding.

No. 1042—SOIL. *Labeled "Soil from an old field, in cultivation since* 1812, *in corn, oats, and tobacco. Farm of Bernard Eskridge, head waters of Otter creek, &c., &c."*

The dried soil is of a dirty, greyish-buff color. It contains fragments of ferruginous chert.

No. 1043—SOIL. *Labeled " Sub-soil of the preceding."*

It contains fragments of chert; is of a dirty-buff color, much lighter than the preceding.

One thousand grains of each of these soils, air-dried, were severally digested in water charged with carbonic acid, for a month, and gave up to it *soluble matters*, as follows:

	No. 1040. Virgin soil.	No. 1041. Sub-soil.	No. 1042. Old field.	No. 1043. Sub-soil.
Organic and volatile matters	0.741	0.267	0.417	0.233
Alumina, and oxides of iron and manganese and phosphates	.231	.031	.121	.047
Carbonate of lime	1.213	.297	.730	.447
Magnesia	.236	.072	.120	.127
Sulphuric acid	not estim'd	not estim'd	.028	.028
Potash	.089	.029	.061	.032
Soda	.023	.019	.028	.017
Silica	.156	.114	.320	.147
Loss	.134	.021	.092	----------
Soluble extract, dried at 212° F., (grains)	2.823	0.850	1.917	1.078

The *composition* of these four soils, dried at 400° F., is as follows:

	No. 1040. Virgin soil.	No. 1041. Sub-soil.	No. 1042. Old field.	No. 1043. Sub-soil.
Organic and volatile matters	5.207	2.865	3.378	2.561
Alumina	2.990	3.540	3.020	2.990
Oxide of iron	2.235	3.260	2.260	2.535
Carbonate of lime	.370	.245	.245	.170
Magnesia	.392	.483	.321	.315
Brown oxide of manganese	.320	.245	.120	.195
Phosphoric acid	.183	.078	.137	.119
Sulphuric acid	.040	.059	.041	.028
Potash	.169	.183	.121	.101
Soda	.042	.063	.040	trace.
Sand and insoluble silicates	88.130	87.570	90.220	90.495
Loss	----------	1.409	.097	.491
Total	100.078	100.000	100.000	100.000
Moisture, lost at 400° F.	2.100	1 750	1.265	1.425

On comparing the composition of the soil from the "old field," with that of the virgin soil, the usual diminution of the essential ingredients will be observed. The sub-soil does not appear to be richer in these mineral ingredients than the surface soil.

No. 1044—Soil. *Labeled "Soil from an old field, thirty years in cultivation, on the farm of Mr. Taber; on the hills two miles south of Big Spring, Hardin county, Ky. Mr. Taber has taken from this soil three crops of tobacco, nine of corn, and nine of wheat. Last year no crop was raised on it. He does not consider it worn out."* (*Obtained by S. S. Lyon, Esq.*)

"This field lies on the top of the intercalated bed of oolitic limestone,

in the millstone grit. The soil is partly derived from the sandstone called Tar Rock, and partly from the limestone under it."

The dried soil is of a greyish-buff, or dirty yellowish-grey color.

No. 1045—SOIL. *Labeled " Sub-soil of the preceding, &c, &c."*

The dried sub-soil is of a greyish-buff color.

One thousand grains of each of these soils, air-dried, were digested for a month in water charged with carbonic acid, to which they gave up the following materials, viz:

	No. 1044. Soil.	No. 1045. Sub-soil.
Organic and volatile matters	0.400	0.443
Alumina, and oxides of iron and manganese and phosphates	.121	.080
Carbonate of lime	.546	.180
Magnesia	.116	.087
Sulphuric acid	.056	.022
Potash	.064	.035
Soda	.035	.050
Silica	.200	.147
Soluble extract, dried at 212° F., (grains)	1.538	1.044

The *composition* of these soils, dried at 400° F., is as follows:

	No. 1044. Soil.	No. 1045. Sub-soil.
Organic and volatile matters	3.197	2.615
Alumina	2.015	2.015
Oxide of iron	2.035	2.885
Carbonate of lime	.130	.095
Magnesia	.472	.411
Brown oxide of manganese	.170	.080
Phosphoric acid	.072	.072
Sulphuric acid	.021	.021
Potash	.164	.169
Soda	.021	.049
Sand and insoluble silicates	91.345	89.770
Loss	.358	1.818
Total	100.000	100.000
Moisture, lost at 400° F.	1.475	1.525

The soil and sub-soil do not differ very much in mineral composition. They cannot be considered exhausted, but yet would be much improved by the application of slacked lime, plaster of paris, and bone dust or

super-phosphate of lime, as top-dressings. The phosphoric and sulphuric acids being particularly small in quantity in them.

HENDERSON COUNTY.

No. 1046—LIMESTONE. *Labeled "Limestone, from Mount Zion, Henderson county, Ky. (Coal Measures.")*

A dull, fine-grained, fossiliferous limestone, with a few glimmering facets of calc. spar.

Dried at 212° F., it lost 0.20 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	88.380
Carbonate of magnesia	3.678
Alumina and oxides of iron and manganese	1.760
Phosphoric acid	.246
Sulphuric acid	.166
Potash	.289
Soda	.068
Silex and insoluble silicates	3.280
Water and loss	2.133
	100.000

This limestone contains enough of potash and phosphoric and sulphuric acids, &c., to make it valuable as a top-dressing to exhausted soils; at the same time it is pure enough to be burnt for building purposes.

HENRY COUNTY.

No. 1047—BONES OF MASTODON. "*Eminence, Henry county, Ky.*"

A fragment of one of the vertebræ. Exterior surface of a dirty buff-grey color; adheres strongly to the tongue. *Cancellæ* of the interior lined with a ferruginous infiltration. Dried at 212° F., it lost 6.56 per cent. of *moisture*, after having been thoroughly air-dried.

COMPOSITION, DRIED AT 212° F.

Phosphoric acid	23.603	of which 13.546 was combined with lime and magnesia, and 10.057 was united with alumina and oxide of iron.
Sulphuric acid	.509	
Chlorine	a trace.	
Hydro-fluoric acid	not estimated.	
Lime combined with phosphoric acid	15.189	=28.322 phosphate of lime (3 CaO, PO5)
Magnesia combined with phosphoric acid	.231	= .644 phosphate of magnesia.
Carbonate of lime	25.680	
Oxides of iron and manganese	15.980	
Alumina	3.780	
Potash	.347	
Soda	.218	
Silex and insoluble silicates	13.620	
Organic matter ? and loss	.843	
	100.000	

No. 1048—(a. and b.) "FRAGMENT OF TOOTH OF MASTODON. *Eminence, Henry county, Ky.*"

Portion of one of the tubercles of the grinders. *Enamel,* yet hard and shining; nearly white; not adhering to the tongue. *Interior osseous portion* adheres strongly to the tongue; friable; grey, and dark-grey in parts.

Interior portion (a) lost 4.86 per cent. of *moisture* at 212° F.

Enamel (b) lost 1.20 per cent. of *moisture* at 212° F.

Neither contained enough organic matter to blacken when ignited.

COMPOSITION, DRIED AT 212° F.

	No. 1048 (a). Interior Osseous portion.	No. 1048 (b). Enamel.
Phosphate of lime	80.576	92.070
Phosphate of magnesia	1.284	1.084
Carbonate of lime	13.720	2.300
Magnesia	.366	.166
Chlorine	a trace.	a trace.
Hydro-fluoric acid	not estimated.	not estimated.
Sulphuric acid	.588	.248
Potash	.139	.173
Soda	.467	.633
Silex and insoluble silicates	.124	.124
Water and loss, &c.	2.736	3.202
	100.000	100.000

Most of the *loss* stated above is believed to be of *magnesia;* a very small proportion only being organic matter.

No. 1049—CLAY. *Labeled "Clay in which bones of mastodon are found, at Eminence, Henry county, Ky."*

A light, grey colored clay, when dry, with ferruginous discolorations in places.

No. 1050—CLAY. *Labeled "Ferruginous Clay, over and mixed with the clay of the mastodon bed, Eminence, Henry county, Ky."*

A friable ochreous earth; generally of a brownish-yellow color, with pores and cavities lined with dark brown oxide of iron.

COMPOSITION OF THESE CLAYS, DRIED AT 212° F.

	No. 1049. Bone clay.	No. 1050. Ferrug.clay
Sand and insoluble silicates	80.380	46.480
Alumina with a little oxide of iron	11.650	----------
Oxide of iron with some alumina	----------	40.172
Carbonate of lime	.780	a trace.
Magnesia	.933	.566
Phosphoric acid	.310	3.128
Sulphuric acid	.304	.304
Potash	.490	.463
Soda	.257	.141
Water and loss	4.896	8.746
Total	100.000	100.000
Moisture expelled at 212° F.	4.060	4.900

HOPKINS COUNTY.

No. 1051—Soil. *Labeled "Soil from east side of Whiteside's creek, Hopkins county, Ky. (Coal Measures.") Obtained by S. S. Lyon, Esq.*

The dried soil is of a light umber color. Some few rounded fragments of sandstone were sifted out of it.

No. 1052—Soil. *Labeled "Sub-soil from east side of Whiteside's creek, Hopkins county, Ky. (Coal Measures.")*

Dried soil light umber colored; lighter and more yellowish than the preceding.

No. 1053—Soil. *Labeled "Soil from three miles north of Madisonville, Hopkins county. (Coal Measures.")*

Dried soil brownish grey-buff color.

No. 1054—Soil. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil lighter colored than preceding and of a more pure buff.

No. 1055—Soil. *Labeled "Soil, from near the road, southeast side of Pond creek, Hopkins county. (Coal Measures.")*

Dried soil of a dark, dirty-buff color.

No. 1056—Soil. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil of a brownish-buff color.

One thousand grains of each of these six coal measures soils, thoroughly air-dried, were digested, severally, for a month in water charged

with carbonic acid, to which they gave up the following materials, &c., quantities stated in grains and decimals:

	No. 1051. Soil.	No. 1052. Sub-soil.	No. 1053. Soil.	No. 1054. Sub-soil.	No. 1055. Soil.	No. 1056. Sub-soil.
Organic and volatile matters	2.100	0.717	0.600	0.300	0.566	0.277
Alumina, and oxides of iron and manganese and phosphates	1.930	.540	.296	.060	.257	.080
Carbonate of lime	2.547	.696	.113	.063	1.097	.051
Magnesia	.099	[illegible]	.044	.073	.160	.110
Sulphuric acid	.030	.030	.067	.025	.033	.055
Potash	.107	.081	.064	.037	.133	[illegible]
Soda	.060	.048	.054	.045	.060	.025
Silica	.220	.214	.114	.164	.264	.164
Loss	.040	.591	.425	.083		
Soluble extract, dried at 212° F.	7.133	2.983	1.777	0.850	2.570	0.796

The *composition* of these six soils, dried at 400° F., is as follows:

	No. 1051. Soil.	No. 1052. Sub-soil.	No. 1053. Soil.	No. 1054. Sub-soil.	No. 1055. Soil.	No. 1056 Sub-soil.
Organic and volatile matters	6.263	4.295	3.843	3.756	2.887	[illegible]
Alumina	3.390	4.845	4.165	5.890	3.415	6.590
Oxide of iron	2.700	2.910	2.985	4.700	2.365	4.600
Carbonate of lime	.445	.160	.095	.070	.220	.045
Magnesia	.491	.507	.393	.584	.344	.656
Brown oxide of manganese	.295	.370	.290	.120	.095	.170
Phosphoric acid	.148	.078	.118	.096	.173	.053
Sulphuric acid	.076	.059	.025	.016	.016	.033
Potash	.158	.330	.225	.323	.198	.331
Soda	.034	.113	.090	.047	.073	.067
Sand and insoluble silicates	85.970	86.070	[illegible]	84.445	90.745	[illegible]
Loss	.030	.263				
Total	100.000	100.000	100.164	100.047	100.551	[illegible]
Moisture, lost at 400° F.	2.600	1.900	1.775	2.150	1.300	1.915

The sub-soils are generally richer in potash and magnesia, and poorer in lime and phosphoric and sulphuric acids, than the surface soil. They contain also larger proportions of alumina and oxide of iron.

No. 1057—COAL. *Labeled "Arnold's Coal, bed eight feet thick, four and a half miles south of Madisonville, Hopkins county, Ky."*

A pure shining, deep-pitch-black coal; iridescent in parts. Brittle. Fibrous coal between some of the layers; the surfaces of which are generally irregular and shining. Over the spirit lamp it swells up, aggluti-

nates; burns with a very smoky flame, and leaves a light coke. Specific gravity 1.274.

PROXIMATE ANALYSIS.

Moisture	4.00	Total volatile matters	41.50
Volatile combustible matters	37.44		
Fixed carbon in the coke	54.80	Moderately light coke	58.50
Grey ashes	3.76		
	100.00		100.00

The percentage of *sulphur* is 2.796.

JACKSON COUNTY.

No. 1058—SOIL. *Labeled "Virgin Soil, on dividing ridge between Jackson and Estill counties, farm of Wm. Roberts; head waters of Grassy branch of Sturgeon creek, Jackson county, Ky. Geological position: top of the millstone grit ridge; above the sandstone cliffs."* (*Obtained by Jos. Lesley, jr., Esq.*)

Dried soil of a greyish-buff color. Some fragments of ferruginous sandstone were sifted out of it.

No. 1059—SOIL. *Labeled "Surface Soil, field adjoining the preceding; cleared four or five years ago; in corn ever since, &c., &c."*

Dried soil of a greyish-buff color; lighter than the preceding. Some iron gravel and ferruginous sandstone were sifted out of it with the coarse seive.

No. 1060—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried soil of a light greyish-buff color; lighter than the preceding. It also contained some iron gravel and fragments of ferruginous sandstone.

One thousand grains of each of these soils were digested, severally, for a month, in water charged with carbonic acid, which extracted the following materials; stated in grains and decimals:

	No. 1058. Virgin soil.	No. 1059. Old field.	o. 1060. Sub-soil.
Organic and volatile matters	0.917	0.700	0.467
Alumina, and oxides of iron and manganese and phosphates	.813	.463	.246
Carbonate of lime	.130	.497	.163
Magnesia	.090	.159	.060
Sulphuric acid	.028	.034	.045
Potash	.045	.093	.148
Soda	.042	.052	.035
Silica	.147	.281	.314
Loss	.238	.204	.002
Soluble extract, dried at 212° F., (grains)	2.450	2.483	1.500

The *composition* of these soils, dried at 400° F., is as follows:

	No. 1058. Virgin soil.	No. 1059. Old field.	No. 1060. Sub-soil.
Organic and volatile matters	4.998	3.390	2.433
Alumina	5.560	3.035	5.583
Oxide of iron	2.970	1.860	
Carbonate of lime	.011	.031	.011
Magnesia	.444	.298	.117
Brown oxide of manganese	.120	.045	----------
Phosphoric acid	.126	.062	.142
Sulphuric acid	.042	trace.	.016
Potash	.243	.232	.238
Soda	.074	.012	.078
Sand and insoluble silicates	85.860	91.160	90.995
Loss	----------	----------	.387
Total	100.448	100.125	100.000
Moisture, lost at 400° F.	1.915	1.115	0.965

This land would be improved by top-dressings of lime and of plaster of paris.

No. 1061—SOIL. *Labeled "Virgin Soil, from the land of Mr. Sloan, (opposite his house,) on Indian Fork of Rockcastle river, Jackson county, Ky., four miles from McKee, on the Big Hill and Richmond road. Geological position: slopes of the coal-bearing shales and sandstones; the soil has been formed from these and of the debris of the massive sandstone of the millstone grit; between which and the sub-carboniferous limestone they lie." (Obtained by Joseph Lesley, jr.)*

Dried soil of a light yellowish-umber color. Some ferruginous sandstone and gravel iron ore were sifted out of it with the coarse seive.

No 1062—SOIL. *Labeled "Surface Soil from an adjoining field which has been in cultivation six years; now in corn," &c, &c.*

Dried soil of a light yellowish-umber color; a slight shade darker than the preceding. It contained, also, fragments of ferruginous sandstone and gravel iron ore.

No. 1063—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried soil of a light yellowish-umber color; much like the preceding. Contains fragments of ferruginous sandstone and gravel iron ore.

One thousand grains of each of these soils, digested for a month in water containing carbonic acid, severally, yielded the following quantities of soluble matters, viz:

	No. 1061. Virgin soil.	No. 1062. Old field.	No. 1063. Sub-soil.
Organic and volatile matters	1.067	1.883	0.450
Alumina, and oxides of iron and manganese and phosphates	1.163	1.030	.480
Carbonate of lime	.580	1.140	.230
Magnesia	.141	.161	.133
Sulphuric acid	.030	.022	.022
Potash	.066	.135	.173
Soda	.068	.037	.042
Silica	.381	.297	.364
Loss	.337	.045	.389
Soluble extract, dried at 400 F., (grains)	3.833	4.750	2.283

The *composition* of these soils, dried at 400° F., is as follows:

	No. 1061. Virgin soil.	No. 1062. Old field.	No. 1063. Sub-soil.
Organic and volatile matters	.4737	6.425	4.812
Alumina	9.210	6.320	6.870
Oxide of iron		3.360	3.710
Carbonate of lime	.080	.110	.180
Magnesia	.306	.529	.456
Brown oxide of manganese	---------	.270	.120
Phosphoric acid	.176	.194	.160
Sulphuric acid	.050	.045	.050
Potash	.373	.306	.521
Soda	.085	.070	.083
Sand and insoluble silicates	84.620	82.870	83.270
Loss	.363	---------	---------
Total	100.000	100.499	100.232
Moisture, lost at 400° F.	1.850	2.500	2.035

The considerable proportion of *potash* in these soils was doubtless derived from the shales of the coal measures. The amount of lime in them being much below the average, they would doubtless be improved by the application of slacked lime as manure.

No. 1064—Coal. *Labeled "Coal from the land of Mr. Isaacs, on Birch Lick Fork of Indian creek, Jackson county, Ky. Geological position: fifty feet above the sub-carboniferous limestone."* (*Obtained by Joseph Lesley, jr.*)

A fine, deep, pitch-black coal. Some fibrous coal between the layers. Exterior surface coated with ochreous. Over the spirit lamp it softens, agglutinates, and swells into a spongy coke, giving much smoky flame. Specific gravity, 1.290.

PROXIMATE ANALYSIS.

Moisture	1.10	Total volatile matters	39.30
Volatile combustible matters	38.20		
Fixed carbon in the coke	50.80	Moderately light coke	60.70
Light-grey ashes	9.90		
	100.00		100.00

The percentage of *sulphur* is 0.962.

COMPOSITION OF THE ASH.

Silica	3.784
Alumina, and oxides of iron and manganese and trace of phosphates	4.680
Carbonate of lime	.184
Magnesia	.346
Sulphuric acid	.097
Potash	.077
Soda	.237
Loss	.495
	9.900

JEFFERSON COUNTY.

No. 1065—LIMESTONE. *Labeled "Variegated Limestone; near the base of the Upper Silurian, of Jefferson county, three miles from Middletown, on the Shelbyville road."*

A fine-granular limestone, of a brownish-yellow, or dirty-orange color, mottled and striped with greenish-grey. Powder light-yellowish. Dried at 212° F., it lost 0.35 per cent. of *moisture.*

COMPOSITION, DRIED AT 400° F.

Carbonate of lime	52.080
Carbonate of magnesia	31.473
Alumina, and oxides of iron and manganese	4.473
Phosphoric acid	.208
Sulphuric acid	.303
Potash	.606
Soda	.307
Silex and insoluble silicates	10.480
	100.009

This magnesian limestone would no doubt prove a durable building stone; if the protoxide of iron in it, which gives to it the greenish color, does not by oxidation cause any exfoliation. It deserves trial as a *hydraulic* limestone; and would no doubt be valuable for agricultural purposes; as a manure to exhausted land; in its burnt and slacked, or powdered condition.

No. 1066—LIMESTONE. *Labeled "Hydraulic? Limestone, Chenowick creek, Jefferson county. (Upper Silurian.")*

A fine-granular, dull, greenish-grey rock. Adheres slightly to the tongue. Dried at 212° F., it lost 0.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	42.819=24.118 lime.
Carbonate of magnesia	21.819=10.395 magnesia.
Alumina, and oxides of iron and manganese	6.560
Phosphoric acid	.214
Sulphuric acid	1.284
Potash	.233
Soda	.372
Silex and insoluble silicates	23.980
Water and loss	2.558
	100.000

This is probably a good hydraulic limestone.

No. 1067—LIMESTONE. *Labeled "Hydraulic Cement, overflowed in the bin in* 1832; *since then exposed to the atmosphere. Hardened without sand, under water. Old Mill: Canal at Louisville. How much water? Does it contain hydrated silicate of lime?"*

Of a light-grey color; quite firm and hard; adheres slightly to the tongue; uneven; somewhat hackly fracture.

Dried at 212°, it lost 4.80 per cent. of *moisture* in its air-dried state.

COMPOSITION, DRIED AT 212° F.

Lime	28.260=50.260 carbonate of lime.
Magnesia	10.095
Carbonic acid	22.140
Phosphoric acid	.156
Sulphuric acid	not estimated.
Alumina, and oxides of iron and manganese	10.460
Potash	.214
Soda	.672
Soluble silica	6.340
Insoluble silica	11.380
Combined water	10.340
	100.057

The solution of this cement in hydrochloric acid gelatinized on evaporation. The quantity of *soluble silica*, indicated above, shows how much had chemically combined with the lime (or magnesia, or both) in the form of *silicate*. It is believed that the property of hardening under water is due to the formation of *silicates* of lime, or magnesia, in the act of burning the lime; and it is probable that the considerable proportions of *potash* and *soda* usually found in hydraulic limestones, aid in the production of these compounds. Moreover, almost all the best water cements contain considerable quantities of *magnesia*, and it would seem that this earth sometimes communicates *hydraulic* properties to limestones which contain only a small proportion of silicious matter.

No. 1068—LIMESTONE. *Labeled "Banded Building Stone; seventy-five feet above the Dean Marble; used in the construction of the Court-House at Louisville, Ky. From Madison, Indiana, quarries. Hydraulic limestone?"*

A dull, fine-granular rock, with horizontal bands of reddish and greenish grey-buff colors. Adheres slightly to the tongue. Specific gravity 2.7562.

Dried at 212°, it lost 0.46 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	45.880=25.746 per cent. of lime.
Carbonate of magnesia	22.911=10.914 per cent. of magnesia
Alumina, and oxides of iron and manganese	5.760
Phosphoric acid	.220
Sulphuric acid	.269
Potash	.347
Soda	.372
Silica, soluble in boiling solution of carbonate of soda	3.000
Silica, insoluble in boiling solution of carbonate of soda	18.520
Water and loss	2.721
	100.000

This, having the composition of a good water-lime, or hydraulic limestone, was tested, by burning some for two days at a moderate red heat; pulverizing and mixing with sand and water; and it was found to harden very well under water. Some of the calcined rock, dissolved in hydrochloric acid, formed a solution which gelatinized on partial evaporation, proving the presence of soluble silicates.

The *composition* of the *calcined* portion was found to be as follows:

Lime	38.718
Magnesia	15.337
Alumina, and oxides of iron and manganese, (with some magnesia)	14.960
Silica, soluble in boiling carb. soda solution	14.160
Silica, insoluble in boiling carb. soda solution	14.880
Alkalies and acids (not estimated) and loss	1.945
	100.000

There is no doubt that this would make good hydraulic cement, if properly calcined and prepared. But experience has proved that these porous, absorbent, hydraulic limestones are unfit for architectural purposes, in consequence of their rapid disintegration, by scaling from the surface, under the influence of moisture and frost.

No. 1069—Marl. *Labeled Marl? from Chenowick creek, Jefferson county, Ky.*"

A greenish-grey, clay-like substance; with some thin brownish infiltrations.

Dried at 212° F., it lost 0.90 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	26.880
Carbonate of magnesia	1.687
Alumina, and oxides of iron and manganese	7.260
Phosphoric acid	.694
Sulphuric acid	.406
Potash	.965
Soda	.012
Silex and insoluble silicates	59.900
Combined water, expelled by ignition	2.196
	100.000

This would prove a valuable application to exhausted land.

No. 1070—Soil. *Labeled "Virgin Soil; eight inches of the surface, taken immediately under the sod of native blue-grass, in Woodland pasture. Principal growth walnut, with black locust, wild cherry, elm, ash, hackberry, box-elder, buckeye, pignut and shellbark hickory, coffee-nut, red and over-cup oak, large sugar maple, and root-covered beech. Farm of Theodore Brown, six miles east of Louisville, on the Lexington turnpike, waters of Middle Fork of Beargrass creek, Jefferson county, Ky." Upper Silurian formation.* (Some of the best "Beargrass" land.)

Dried soil of a dark, dirty-buff color.

No. 1071—Soil. *Labeled "Sub-soil, (ten inches,) from immediately under the preceding, &c., &c."*

Dried soil much lighter and more yellowish than the preceding.

No. 1072—Soil. *Labeled "Ten inches of the top soil from an old field about thirty years in cultivation. For eleven successive years in hemp; (the last crop averaging 900 pounds to the acre,) and the remainder of the time in hemp in rotation with corn, wheat, and clover. Farm of Theodore Brown, Jefferson county, Ky., &c., &c."*

Dried soil of a color like that of the virgin soil, a slight shade darker than that.

No. 1073—Soil. *Labeled "Ten inches of the sub-soil of the preceding, &c., &c."*

Color like that of the sub-soil of the virgin soil.

No. 1074—Soil. *Labeled "Eight inches of the top-soil of a field which has been cultivated about seventy years; for the first thirty years in corn, and the remaining forty years in this crop alternating with wheat, clover, and hemp. Farm of Theodore Brown, Jefferson county, &c., &c."*

Color of the dried soil slightly lighter than that of the virgin soil.

No. 1075—Soil. *Labeled "Ten inches of the sub-soil of the old field next preceding, &c., &c."*

The soluble materials extracted from one thousand grains of each of these soils, severally, by digestion for about a month in water charged with carbonic acid, may be summed up as follows:

	No. 1070. Virgi soil.	No. 1071. Sub-soil.	No. 1072. Soil 30 yr. old field.	No. 1073. Sub-soil.	No. 1074. Soil 70 yr. old field.	No. 1075. Sub-soil.
Organic and volatile matters	0.600	0.300	0.467	0.270	0.466	0.127
Alumina, and oxides of iron and manganese and phosphates	.114	.047	.081	.047	.131	.031
Carbonate of lime	1.580	.747	1.730	.780	.897	.577
Magnesia	.144	.111	.105	.111	.143	.094
Sulphuric acid	.028	.022	.081	.033	.022	.054
Potash	.103	.066	.077	.031	.106	.051
Soda	.040	trace.	.023	trace.	.059	trace.
Silica	.131	.187	.147	.114	.200	.121
Loss	.043	----------	.355	.114	.096	----------
Soluble extract, dried at 400° F.	2.783	1.480	3.066	1.500	2. 20	1.055

The *composition* of these six soils, dried at 400° F., is as follows, viz:

	No. 1070. Virgin soil.	No. 1071. Sub-soil.	No. 1072. Soil of 30 yr. old field.	No. 1073. Sub-soil.	No. 1074. Soil of 70 yr. old field.	No. 1075. Sub-soil.
Organic & vol. matters	5.173	3.417	5.457	3.406	4.389	3.105
Alumina	2.900	3.665	2.365	3.365	2.890	4.115
Oxide of iron	3.085	3.410	2.510	3.410	2.985	3.320
Carbonate of lime	.370	.270	.370	.290	.270	.245
Magnesia	.719	.621	.467	.576	.484	.513
Brown oxide of manganese	.395	.270	.320	.220	.245	.220
Phosphoric acid	.203	.127	.160	.127	.258	.176
Sulphuric acid	.076	.042	.059	.025	.067	.041
Potash	.208	.212	.167	.257	.253	.275
Soda	.154	.077	.072	.127	.026	.047
Sand & insol. silicates	86.370	87.995	87.170	87.795	87.345	87.870
Loss	.347	----------	.883	.402	.788	.073
Total	100.000	100.106	100.000	100.000	100.000	100.000
Moisture, lost at 400° F	2.100	1.650	1.975	1.650	1.685	1.775

The soil of the old field, seventy years in cultivation, appears to be fully as rich as the virgin soil analyzed; whether it was originally richer than that, either on the surface or in its sub-soil, or whether its fertility has been maintained by a judicious system of culture, is not known to the writer. That of the old field, thirty years in cultivation, shows the usual evidence of deterioration, in the decreased quantities of potash, phosphoric acid, sulphuric acid, &c.; but its fertility is indicated by the large amount of *soluble extract* which it gives up to the water charged with carbonic acid; although this *extract* does not contain as large a proportion of *potash* as that from the virgin soil. These Beargrass lands are eminently fertile, and are based on a limestone sub-stratum, which by its gradual decomposition will tend continually to renew its fertility; imparting to it not only carbonates of lime and magnesia, but also potash, phosphoric and sulphuric acids, and other essential elements of vegetable composition. But they do not contain quite as much of these essential elements as the best "bluegrass" land of the Lower Silurian blue limestone region; nor is the limestone on which they rest quite as quickly decomposable as that blue limestone.

No. 1076—MARL. *Labeled "Loose dirt taken from between some of the upper layers of rock in a well on the land of the Rev. George Bickett, adjoining that of Theodore Brown. This abounds in all the neighboring quarries, around and above loose stones and thin sheets. Is it of a marly nature? Jefferson county, Ky., &c., &c."*

Color of the dried earth, like that of the sub-soil of Theodore Brown's land, (next preceding,) a little darker, with whitish particles of decomposed chert mixed with it. Some fragments of soft, decomposing chert were sifted out of it.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than seven and a half grains of yellowish-grey extract,* dried at 400° F., which had the following composition:

Organic and volatile matters	0.560
Alumina, and oxides of iron and manganese and phosphates	.134
Carbonate of lime	5.747
Magnesia	.188
Sulphuric acid	.049
Potash	.411
Soda	.061
Silica	.214
Loss	.402
Extract, dried at 212°	7.766 grains.

The *composition* of this soil, dried at 400° F., is as follows:

Organic and volatile matters	8.284
Alumina, and oxides of iron and manganese	19.310
Carbonate of lime	2.595
Magnesia	.071
Phosphoric acid	.269
Sulphuric acid	.062
Potash	.874
Soda	.090
Sand and insoluble silicates	68.820
	100.375

This marly clay is rich enough in carbonate of lime and potash to make it a valuble mineral manure for land exhausted of these materials.

No. 1077—LIMESTONE. *Labeled "Top layer, usually found at the depth of from five to eight feet below the surface of the ground. (These upper layers are not more than a few inches thick.) Farm of Theodore Brown, &c., &c., Jefferson county, Ky." Upper Silurian or Devonian formation.*

A grey limestone, with the exterior of the layers, to the depth of half an inch or more, of a dirty-grey buff color; sparkling with small crystalline facets, and containing a great number of small entrochites and encrinital stems, with a few bi-valve shells.

No. 1078—LIMESTONE. *Labeled "Same level as the preceding, a more certain representative of the upper layers. Farm of Theodore Brown, &c., &c."*

Resembles the preceding; a little finer in grain. Encrinital stems larger.

No. 1079—LIMESTONE. *Labeled "Layer next to the top; the upper ones being only a few inches thick, and the lower two feet or more. Theodore Brown's farm, &c., &c."*

A light-grey, fine-grained limestone, containing much coral, (Fenestrella,) and some bi-valve shells, (Atrypa?)

No. 1080—LIMESTONE. *Labeled "Blue, or dark-grey Limestone, found one or two feet above the level of Beargrass creek; sometimes in thin layers, but generally in thick ones. Theodore Brown's farm, &c., &c."*

A bluish-grey limestone; dirty-buff on the weathered surfaces; sparkling with facets of calc. spar; containing small encrinital stems and some bi-valve shells.

No. 1081—LIMESTONE. *Labeled "Limestone, full of fossils, resting on the layer which forms the bed of Middle Fork of Beargrass creek. Theodore Brown's farm, six miles east of Louisville, Jefferson county, &c., &c."*

Appears to be made up of fossil shells, corals, &c., mineralized with carbonate of lime. General color light-grey, with some oxide of iron giving it a mottling of yellowish; presenting irregular pores.

These limestones and the preceding soils, were collected and sent for analysis by Mr. Theodore Brown.

The *composition* of these five limestones, dried at 212° F., may be tabulated as follows:

	No. 1077. Top layer.	No. 1078. Top layer.	No. 1079. Next to top layer.	No. 1080. Dark grey blue.	No. 1081. Fossiliferous.
Carbonate of lime	89.060	92.560	82.960	88.061	86.260
Carbonate of magnesia	6.783	4.615	14.014	7.486	2.587
Alumina and oxides of iron and manganese	1.480	.480	.880	.216	.580
Phosphoric acid	.310	trace.	.182	.639	trace.
Sulphuric acid	.475	.166	.272	.647	.132
Potash	.154	.166	.013	.252	.115
Soda	.163	.074	.212	not estimated	.116
Silex and insoluble silicates	2.680	2.580	.880	1.680	9.580
Loss	-----------	-----------	.587	1.001	.730
Total	101.105	100.641	100.000	100.000	100.000
Moisture lost at 212° F.	0.100	0.060	0.060	0.100	0.100

The limestone of the blue or dark-grey layer would prove the best for application to land; because it contains the most phosphoric acid, potash, &c., &c.

LAUREL COUNTY.

No. 1082—CARBONATE OF IRON. *"From the land of John Robeson, seven miles from London; a mile and a quarter west of the Crab Orchard road, on Gillis' branch, a quarter of a mile from the mouth. Layer eighteen inches thick, in the face of a bluff of fifty or sixty feet of coarse grey sandstone. Some distance under the coal beds of London, and just above the upper part of the millstone grit."*

A dense, dull, brownish-grey, fine-granular ore; with a white incrustation in the fissures; and containing a few small specks of yellow iron pyrites. Weathered surfaces brownish. Powder buff-grey.

Dried at 212° F., it lost 0.600 per cent. of moisture.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	72.960=35.284 per cent. of iron.
Alumina	1.980
Carbonate of lime	3.180
Carbonate of magnesia and loss	4.759
Carbonate of manganese	1.264
Phosphoric acid	1.883
Sulphuric acid	.454
Potash	not estimated.
Soda	
Silex and insoluble silicates	13.520
	100.000

Rich enough in iron to be profitably smelted, but containing rather more than the usual proportion of phosphoric acid.

LEWIS COUNTY.

No. 1083—SALINE EFFLORESCENCE. *Labeled "Copperas from Devonian Black Slate, near David Mifford's, eight miles from Clarksburg, Lewis county, Ky."*

Yellowish-white, porous, light lumps of saline efflorescence mixed with small fragments of slate.

COMPOSITION, DRIED AT 212° F.

Sulphate of alumina	25.585
Sulphate of iron	15.653
Sulphate of magnesia	1.000
Alkaline sulphates	8.000
Slate and insoluble portion	1.000
Water and loss	48.762
	100.000

This, if abundant, might be employed in the manufacture of alum; with Venitian red as an incidental product.

No. 1084—FERRUGINOUS LIMESTONE. *Labeled "Ferruginous Calcareous concretion in black shale, mouth of Salt Lick Creek, Lewis county, Ky. Base of the sub-carboniferous formation."*

A dull, umber-colored mineral; imperfectly laminated. Not adhering to the tongue. Powder umber-grey. Specific gravity 2.687.

Dried at 212°, it lost 0.80 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	42.490
Carbonate of magnesia	15.225
Carbonate of manganese	.571
Carbonate of iron	10.632
Oxide of iron	.446
Alumina	1.380
Phosphoric acid	.182
Sulphuric acid	.132
Potash	.560
Soda	.326
Silex and insoluble silicates	23.380
Organic matters and loss	4.6[illegible]

These concretions would, very probably, make very good hydraulic cement, if properly prepared.

No. 1085—Yellow Magnesian Limestone. *Probably belonging to the age of the Upper Silurian. Salt Lick creek, four miles above Clarksburg, Lewis county, Ky.*

A brownish-buff, porous limestone. Exterior surface so soft as to be scratched by the nail, and full of fossil casts of entrochites and bi-valve shells. Interior not adhering to the tongue, and glimmering with numerous facets of yellow-brown calcareous spar. Powder of a grey-buff color.

Dried at 212° F., it lost 0.40 per cent of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	55.240
Carbonate of magnesia	27.820
Alumina, and oxides of iron and manganese	12.280
Phosphoric acid	.207
Sulphuric acid	.152
Potash	.167
Soda	.126
Silex and insoluble silicates	2.580
Water and loss	1.428

No. 1086—Sandstone. *Labeled "Soft Yellow Rock, associated with the Yellow Magnesian Limestone, at the Forks of Salt Lick creek, near Adam Bartram's farm, Lewis county, Ky."*

A soft sandstone of a handsome dark-buff color. Adheres to the tongue. Scratched by the nail. After ignition, it is of a brick-red color. Powder of a handsome buff-color. Dried at 212° F., it lost 2.10 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	90.920
Alumina, and oxides of iron and manganese	5.800
Lime	trace.
Magnesia	.732
Phosphoric acid	.118
Sulphuric acid	.200
Potash	trace.
Soda	trace.
Water, expelled at a red heat	2.100
Loss	.130
	100.000

No. 1087—Soil. *Labeled "Soil derived from the Yellow Magnesian Limestone, under the Black Slate of Lewis county. From the farm of Adam Bartram, near the forks of Salt Lick. Growth white poplar, black walnut; red oak the principal growth."*

Dried soil of a light grey-brown color. Some fragments of yellowish

and brown, soft ferruginous sandstone sifted out of it with the coarse seive.

No. 1088—Soil. *Labeled "Virgin Soil, from the Hendrick farm, on Poplar Ridge; over Magnesian Limestone. Waters of Cabin creek, Lewis county, Ky. Upper Silurian." Primitive growth, poplar, black ash, buck-eye, and sugar-tree.*

Dried soil of a greyish light chocolate color. A few fragments of soft ferruginous sandstone, and small ferruginous concretions, were sifted out of it.

No. 1089—Soil. *Labeled "Same Soil, from an old field fifty to sixty years in cultivation, now in wheat, Hendrick farm, Poplar Ridge, Lewis county, Ky."*

Dried soil of a light yellowish-umber color. Some fragments of ferruginous sandstone and iron gravel were sifted out of it.

No. 1090—Soil. *Labeled "Sub-soil from the same old field, Hendrick farm, Poplar Ridge, Lewis county, Ky."*

Dried soil of a greyish-buff color. Contains rather more iron gravel, &c., than the preceding.

The soluble materials, extracted from one thousand grains of each of these soils, by digestion for a month in water charged with carbonic acid, are as follows:

	No. 1087. Yel. mag. lim't. soil.	No. 1088. Virgin so .	No. 1089. Soil of old field.	No. 1090. Sub-soil.
Organic and volatile matters	0.633	0.820	0.733	0.290
Alumina, and oxides of iron and manganese and phosphates	.361	.100	.413	.173
Carbonate of lime	.030	.930	1.247	.730
Magnesia	.096	.245	.194	.203
Sulphuric acid	.028	.022	.048	.028
Potash	.067	.137	.033	.022
Soda	.048	.024	.068	.049
Silica	.181	.197	.200	.200
Loss	.389	.175	----------	----------
Soluble extract, dried at 212° F., (grains)	1.833	2.650	2.936	1.695

The *composition* of these four soils, dried at 400° F., is as follows:

	No. 1087. Yel. mag. lim't soil.	No. 1088. Virgin soil Hendrick's.	No. 10 9. Old field soil.	No. 1090. Sub-soil.
Organic and volatile matters	4.809	5.915	4.613	4.403
Alumina	2.595	1.865	1.990	4.640
Oxide of iron	4.485	2.340	3.510	3.585
Carbonate of lime	.221	.245	.195	.230
Magnesia	.542	.426	.426	.475
Brown oxide of manganese	.220	.045	.120	.045
Phosphoric acid	.112	.144	.118	.062
Sulphuric acid	.045	.050	.042	.011
Potash	.338	.159	.130	.195
Soda	.050	.005	.063	..127
Sand and insoluble silicates	86.495	88.295	87.470	87.120
Loss	.088	.511	1.323	----------
Total	100.000	100.000	100.000	100.896
Moisture, lost at 400° F.	2.065	2.125	1.850	1.825

LINCOLN COUNTY.

No. 1091—MINERAL WATER. *Labeled "Sulphur Water, sent by Mr. A. M. Bacon, from the place of Mr. Stanton Pollard, on his premises, directly in front of his house; within three rods of the turnpike leading from Crab Orchard to Lancaster: about a mile and an eighth from Crab Orchard. Found by boring seven feet in the rock, which is grey limestone. Surface of the rock six feet below the general surface. Well thirteen feet deep. The water is brought up by a pump. Lincoln county, Ky."*

The *sulphuretted hydrogen* gas contained in this water having been mainly decomposed by carriage, was not estimated; nor was the *carbonic acid* gas, which it contains in notable proportion.

SALINE CONTENTS OF 1000 GRAINS OF THIS WATER.

Carbonate of lime	0.142	held in solution by carbonic acid.
Carbonate of magnesia	.149	
Chloride of sodium	.692	
Chloride of potassium	.022	
Chloride of magnesium	.122	
Carbonate of soda	.018	
Sulphate of lime	a trace.	
Sulphate of potash	.065	
Silica	.010	
	1.220 grains.	

This appears to be a pleasant weak salt-sulphur water.

LIVINGSTON COUNTY.

OZEORO (FORMERLY HOPEWELL) FURNACE ORES, SLAG, PIG IRON, &c. (PROCURED BY MR. JOHN BARTLETT.)

No. 1092—LIMONITE. *Labeled "Brown Ore, Ozeoro Furnace, (formerly Hopewell Furnace,) Livingston county, Ky."*

A dense, dark-brown limonite, in irregular layers, incrusted with yellow and reddish colors. Powder of a yellow-brown color.

No. 1093—LIMONITE. *Labeled "Pot Ore, Ozeoro Furnace, &c., &c."*

A flattened geode of dense, brown limonite, incrusted with yellowish ochreous ore. Powder of a yellow-brown color.

COMPOSITION OF THESE TWO ORES, DRIED AT 212° F.

	No. 1092. Brown ore.	No. 1093. Pot ore.
Oxide of iron	78.310	76.340
Alumina	.780	.180
Lime	a trace.	trace.
Magnesia	.850	.850
Brown oxide of manganese	.684	.884
Phosphoric acid	.630	.438
Sulphuric acid	.166	a trace.
Potash	.154	.126
Soda	.242	a trace.
Silex and insoluble silicates	6.480	8.780
Combined water	11.800	11.900
Loss	----------	.502
Total	100.096	100.000
Percentage of iron	54.840	53.462
Moisture, lost at 212° F.	0.900	0.900

These ores resemble each other a good deal in composition, but the "pot ore" is rather the purer. Both are very good.

No. 1094—LIMESTONE. *Labeled "Blue Limestone used as a flux at Ozeoro Furnace, Livingston county, Ky."*

A dark-grey, fine-granular limestone; sparkling with small facets of calc. spar. Giving a bituminous odor when hammered.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	91.680=51.447 lime.
Carbonate of magnesia	3.168
Alumina, and oxides of iron and manganese	.284
Phosphoric acid	a trace.
Sulphuric acid	.372
Potash	.224
Soda	.024
Silex and insoluble silicates	4.280
	100.032

Dried at 212°, it lost 0.20 per cent. of *moisture.*

With the exception of its 0.372 per cent. of sulphuric acid, this is quite a pure limestone. This, however, does not appear to injure the iron made with it.

No. 1095—SANDSTONE. *Labeled "Hearth-stone from Illinois. Used at Ozeoro Furnace, Livingston county, Ky."*

A reddish-grey sandstone, composed of clear grains of quartz, more or less rounded, mixed with oxide of iron and small scales of mica.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	93.260
Alumina, and oxides of iron and manganese	3.360
Lime	a trace.
Magnesia	.513
Phosphoric acid	a trace.
Sulphuric acid	.132
Potash	.193
Soda	.050
Water, expelled at a red heat	2.100
Loss	.372
	100.000

This is quite a refractory sandstone.

No. 1096—PIG IRON. *Labeled "Grey Iron, from Ozeoro Furnace, &c."*

A moderately coarse-grained grey iron, with brilliant specular scaly grains. Small fragments extend a little under the hammer, but soon break to pieces. Yields easily to the file.

No. 1097—PIG IRON. *Labeled "Lively Grey Iron, Ozeoro Furnace, &c."*

A little finer-grained, and a little lighter colored specular grey iron than the preceding. Yields easily to the file, and flattens a little under the hammer.

No. 1098—PIG IRON. *Labeled "Close (Hard) Iron, Ozeoro Furnace, &c., &c."*

A very fine-grained light-grey iron; yields with some difficulty to the file; flattens a little under the hammer.

COMPOSITION OF THESE THREE SAMPLES OF IRON.

	No 1096. Grey iron.	No. 1097. Lively grey iron.	No. 1098. Close iron.
Iron	91.714	92.548	93.459
Graphite	2.624	2.524	1.984
Combined carbon	1.700	1.380	2.360
Manganese	.634	.417	.201
Silicon	1.796	1.853	.892
Slag	.244	.384	.184
Aluminum	.063	.095	.202
Calcium	trace.	trace.	trace.
Magnesium	.263	.222	.165
Potassium	.089	.092	.096
Sodium	.012	trace.	.006
Phosphorus	.755	.671	.502
Sulphur	.053	.061	.071
Loss	.053	----------	----------
Total	100.000	100.247	100.122
Total carbon	4.324	3.904	4.344
Specific gravity	7.0291	7.0824	7.2950

No. 1099—IRON FURNACE SLAG. *Labeled "Cinder from the Grey Iron, Ozeoro Furnace, Livingston county, Ky."*

Perfectly vitrified; of a handsome smoky-purple color, streaked with lighter shades of greyish-blue. Transparent in the thin edges. Before the blow-pipe, it melts readily into a whitish, blebby globule.

No. 1100—IRON FURNACE SLAG. *Labeled "Cinder from the Lively Grey Iron, Ozeoro Furnace, &c."*

Dark bottle-green; perfectly vitrified, with some streaks of light grey-blue. Transparent on the thin edges. Before the blow-pipe fuses into a bottle-green globule without frothing. Not quite as fusible as the preceding.

No. 1101—IRON FURNACE SLAG. *Labeled "Cinder from the Close (Hard) Iron, Ozeoro Furnace, &c."*

Olive-grey with streaks of bluish; filled with small air-bubbles, and involving graphite and lumps of whitish material, probably chert.

Translucent on the thin edges. Before the blow-pipe, it is less fusible than the preceding; melting into a blebby globule.

COMPOSITION OF THESE THREE SAMPLES OF "CINDER."

	No. 1099. Cinder from the grey iron.	No. 1100 Cinder from lively grey iron.	No. 1101. Cinder from the close iron.
Silica	62.580	63.380	63.380
Alumina	7.380	8.960	9.560
Lime	25.465	20.751	19.461
Magnesia	1.244	1.462	2.543
Protoxide of iron	.882	3.456	2.914
Protoxide of manganese	.539	.450	.487
Potash	1.313	1.649	1.680
Soda	.905	.207	.202
Total	100.308	100.315	100.227
Proportion of the oxygen in the bases to the oxygen in the silica As	11.959 : 32.493 or 1 : 2.717	11.881:32.909 or 1 : 2.790	12.074:32.909 or 1 : 2.725

The presence of sulphur and phosphorus in these slags was not verified although they are no doubt present. It will be seen, in these analyses, how deficiency of lime in the flux tends to the formation of white iron, and a bottle-green cinder; and how an excess of protoxide of iron supplies to some extent the deficiency of the lime in the flux.

LYON COUNTY.

MAMMOTH FURNACE ORES, PIG IRON, SLAG, LIMESTONE, &c. OBTAINED BY MR. JOHN BARTLETT.

No. 1102—LIMONITE. *Labeled "Brown Ore, (bed A,) within half a mile of Mammoth Furnace, Lyon county, Ky."*

A dense, dark-brown limonite, in pretty thick irregular layers; not adhering to the tongue; involving small irregular cavities, and incrusted with yellowish and reddish ochreous ore. Powder of a yellow-brown color.

No. 1103—LIMONITE. *Labeled "Brown Ore, (bed B,) Mammoth Furnace, &c."*

Resembles the last; rather darker colored in the dense layers. Powder yellowish-brown.

No. 1104—LIMONITE. *Labeled "Brown Ore, (bed C,) Mammoth Furnace, &c."*

A dense, dark-brown limonite; not adhering to the tongue; portions of the surface presenting a glazed appearance, almost black; surface

generally covered with cinnamon-colored ochreous ore. Powder of a yellowish-brown color.

No. 1105—LIMONITE. *Labeled "Brown Ore, (bed D,) Mammoth Furnace, &c."*

The specimen is a large mass of dense, dark-brown limonite; not adhering to the tongue; incrusted with greyish-salmon colored and reddish ochreous material. Powder yellowish-brown.

No. 1106—LIMONITE. *Labeled "Brown Ore, (bed E,) Mammoth Furnace, &c., &c."*

A dense, dark-brown limonite; not adhering to the tongue; in irregular layers, covered with greyish-buff ochreous material. Powder yellowish-brown. Specific gravity 4.2425.

No. 1107—LIMONITE. *Labeled "Honey-comb Ore, not worked at present. Mammoth Furnace, &c."*

A porous (or cellular) mass made up of very thin layers of dense dark-brown limonite, with irregular small cavities between them, incrusted with reddish and yellowish and grey-buff ochreous material. Powder yellowish-brown.

No. 1108—LIMONITE. *Labeled "Brown Ore, (No. 11,) from a bed not worked at present, Mammoth Furnace, &c., &c."*

A dense, dark-brown limonite in thick layers; not adhering to the tongue; including very small flattened cavities; some of which are lined with small white quartz crystals. Exterior covered with brownish and yellowish ochreous ore. Powder brownish yellow.

COMPOSITION OF THESE SEVEN LIMONITES, DRIED AT 212° F.

	No. 1102. Brown ore Bed A.	No. 1103 Brown ore Bed B.	No. 1104. Brown ore Bed C.	No. 1105. Brown ore Bed D.	No. 1106. Brown ore Bed E.	No. 1107. Honey-comb ore.	No. 1108. Brown ore No. 11.
Oxide of iron	78.000	74.547	76.425	64.433	72.356	64.269	76.880
Alumina	.480	1.080	.440	.880	.480	.580	1.130
Lime	trace.	trace.	trace.	trace.	trace.	trace.	trace.
Magnesia	.407	.479	.441	.446	.443	.479	.795
Brown oxide of manganese	1.084	.280	.380	.180	.480	.680	1.060
Phosphoric acid	.758	1.399	.615	.807	.502	.871	.887
Sulphuric acid	.097	.132	.132	.200	.097	.180	.098
Potash	.424	.251	.143	.135	.328	.251	.502
Soda	.120	.207	.145	.016	.255	.002	.109
Silex and insoluble silicates	9.480	10.680	10.980	23.920	13.480	21.880	6.680
Combined water	10.820	11.100	11.100	9.700	11.300	10.500	11.700
Loss	------	------	------	------	.279	.308	.139
Total	101.670	100.155	100.801	100.717	100.000	100.000	100.000
Percentage of iron	54.622	52.206	53.523	45.123	51.022	44.939	53.840
Moisture, lost at 212° F.	0.700	0.700	0.600	0.600	0.700	1.000	0.900

A comparison of the various Mammoth furnace ores can easily be made in the foregoing table. From the considerable proportion of phosphoric acid and the small amount of alumina present in these, generally, it is probable that the use of pure clay, or other argillaceous material, with the flux, with more lime than is generally employed here, would improve the quality of the iron made at this furnace; by removing some of the phosphoric acid, and thus making the iron purer and more tough.

No. 1108 (*a*)—LIMESTONE. *Labeled "Limestone used as a flux at Mammoth Furnace, Lyon county, Ky."*

A dark-grey, or lead-colored fossiliferous limestone, presenting numerous shining facets of calc. spar. Gives out a bituminous odor when hammered. Powder of a light-grey color.

Dried at 212°, it lost 0.140 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	86.380=54.084 lime.
Carbonate of magnesia	.542
Alumina, and oxides of iron and manganese	1.960
Phosphoric acid	.002
Sulphuric acid	.887
Potash } Soda }	not estimated.
Silex and insoluble silicates	8.680
Organic matter and loss	1.549
	100.000

The only objection to the use of this limestone as a flux is in the considerable proportion of sulphuric acid which it contains. This, however, is not likely to leave the limestone, to contaminate the iron with its sulphur, when an excess of lime is present.

No. 1109—PIG IRON. *Labeled "Grey Iron. Foundry Iron, (cold blast,) Mammoth Furnace, &c."*

A moderately fine-grained dark-grey iron. Small fragments extend a little under the hammer; but soon break to pieces. Yields to the file.

No. 1110—PIG IRON. *Labeled "Lively Grey Iron. (Sharp Iron.) Cold blast, Mammoth Furnace, &c."*

Finer-grained; lighter colored, and less tough than the preceding. Yields to the file.

No. 1111—PIG IRON. *Labeled "White Iron, (cold blast,) Mammoth Furnace, &c.; very little made."*

Hard, white: small fragments breaking under the hammer with scarcely any flattening. Homogeneous on the fractured surface; with the appearance of confused radiated bladed crystallization from the lower portion of the pig to the upper surface. Too hard to be filed. Dissolves in acids, and by means of iodine, with great difficulty.

COMPOSITION OF THESE THREE SAMPLES OF PIG IRON.

	No. 1109. Grey iron.	No. 1110. Lively grey iron.	No. 1111. White iron.
Iron	93.096	92.464	93.251
Graphite	2.660	2.800	none.
Combined carbon	1.140	1.500	4.500
Manganese	.421	.233	.276
Silicon	1.681	1.104	.094
Slag	.384	.384	.484
Aluminum	.255	.201	.095
Calcium	a trace.	trace.	trace.
Magnesium	.272	.189	.228
Potassium	.064	.080	.134
Sodium	.070	.145	.135
Phosphorus	.781	1.065	1.346
Sulphur	.080	.080	.080
Total	100.904	100.245	100.623
Total carbon	3.800	4.300	4.500
Specific gravity	6.8529	7.0376	7.4097

No. 1112—IRON FURNACE SLAG. *Labeled "Slag from the Grey Iron, Mammoth Furnace, &c."*

A pretty fusible slag; varying from dark, smoky blue, without vesicles, to greyish-green, filled with small air-bubbles.

No. 1113—IRON FURNACE SLAG. *Labeled "Slag from the Lively Grey Iron, Mammoth Furnace, &c."*

Varying, from *compact*, dark, smoky-blue and bottle-green, to *vesicular*, of light greenish-blue and olive-grey colors. Moderately fusible before the blow-pipe; the bluish into a light bottle-green glass, and the olive-grey into a white vesicular globule.

No. 1114—IRON FURNACE SLAG. *Labeled "Slag from the White Iron, Mammoth Furnace, &c."*

A grey-green, opake, vesicular slag; involving unburnt charcoal and metalic iron. Moderately fusible.

COMPOSITION OF THESE THREE SLAGS.

	No. 1112. Slag from the grey iron.	No. 1113. Slag from the lively grey iron.	No. 1114. Slag from the white iron.
Silica	64.880	65.080	60.280
Alumina	3.980	8.040	5.800
Lime	22.772	20.190	13.288
Magnesia	1.358	.877	.948
Protoxide of iron	3.258	4.158	16.525
Protoxide of manganese	.446	.541	.651
Phosphoric acid	not estimated.		
Sulphuric acid	.289	.290	.324
Potash	1.854	1.398	1.676
Soda	.375	.365	.397
Loss	.788	----------------	.111
Total	100.000	100.939	100.000
Proportion of the oxygen in the bases to the oxygen in the silica — As	10.108:33.687 or 1:3.332	11.217:33.791 or 1:3.012	11.065:31.299 or 1:2.828

The composition of these slags approaches to that of a *tri-silicate;* that is, the oxygen in the bases, lime, magnesia, alumina, &c., &c., is only about one third of that contained in the silica. The iron would be purer if enough lime and some pure aluminous material were added to make the slag a *bi-silicate.* A great deficiency of lime is to be observed in the slag from the *white iron;* which caused the production of that kind of metal, as well as the loss of more than sixteen per cent. of protoxide of

iron in the cinder. With the use of more lime there would be less loss of iron in the slag.

ORE, PIG IRON, SLAG, &C., FROM KELLY & CO.'S IRON WORKS, (SUWANNEE FURNACE,) LYON COUNTY, KY. OBTAINED BY MR. JOHN BARTLETT.

No. 1115—LIMONITE. *Labeled "Iron Ore from Iron Mountain Bank, three miles west of the furnace, Kelly & Co.'s Iron Works, (Suwannee Furnace,) Lyon county, Ky."*

A dense, very dark-brown limonite; not adhering to the tongue. A portion presenting shining mamillary concretions, with a brilliant semi-crystalline fracture. Powder dark, dull Spanish-brown color.

Dried at 212°, it lost 0.90 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Oxide of iron	85.637	=59.973 per cent. of iron.
Alumina	.580	
Lime	a trace.	
Magnesia	.690	
Brown oxide of manganese	1.280	
Phosphoric acid	1.143	
Sulphuric acid	.306	
Potash	.463	
Soda	.195	
Silex and insoluble silicates	4.480	
Combined water	5.900	
	100.674	

This ore contains a little protoxide of iron.

No. 1116—LIMESTONE. *Labeled "Limestone from Baker Spring quarry, two miles from the furnace, used as a flux at Suwannee Furnace, (Kelly & Co.'s,) Lyon county, Ky."*

A dark, umber-grey limestone; showing on the fractured surface shining crystalline facets of calc. spar. Gives a bituminous odor when hammered. Powder of a light-grey color.

Dried at 212° F., it lost 0.200 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	73.580	=41.29 per cent. of lime.
Carbonate of magnesia	17.485	
Alumina, and oxides of iron and manganese	2.240	
Phosphoric acid	.079	
Sulphuric acid	.558	
Potash	not estimated.	
Soda	not estimated.	
Silex and insoluble silicates	4.880	
Loss	1.178	
	100.000	

No. 1117—SANDSTONE. *"Used for Hearth-stone, at Suwannee Furnace, brought from Caseyville, Union county, Ky."*

A friable, light-grey sandstone. Some yellowish ferruginous bands in parts. Under the lens, it appears made up of small clear rounded quartz grains, with no cement. Some few small black specks, and minute scales of mica in it, and some of the grains are discolored with oxide of iron.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	98.080
Alumina, and oxides of iron and manganese	.440
Lime	a trace.
Magnesia	.466
Phosphoric acid	a trace.
Sulphuric acid	.066
Potash	.328
Soda	.255
Water, expelled at a red heat	.600
	100.235

Quite a refractory sandstone; well suited for hearth-stones.

No. 1118—IRON FURNACE SLAG. *Labeled "Slag from Suwannee Furnace, Lyon county, Ky."*

Varying from bottle-green and bluish, *dense* slag, to *vesicular*, light greenish-grey. Quite fusible before the blow-pipe, into a light bottle-green glass.

COMPOSITION:

Silica	61.180	Containing oxygen 31.766
Alumina	5.360	2.515
Lime	23.333	6.635
Magnesia	1.071	.428
Protoxide of iron	4.410	.978
Protoxide of manganese	.818	.206
Phosphoric acid not estimated, (some present.)		
Sulphuric acid	.269	
Potash	1.661	.281
Soda	.176	.045
Loss	1.702	11.088
	100.000	

The oxygen in the bases is to that in the silica, as	11.088 is to 31.766
or as	1. is to 2.866

This slag is very nearly a tri-silicate. By the use of more lime to bring it to the condition of bi-silicate, the quality of the iron would doubtless be improved.

No. 1119—PIG IRON. *Labeled "Very Grey Iron, Suwannee Furnace, Kelly & Co., Lyon county, Ky."*

A very fine-grained grey iron. Small fragments flatten a little under the hammer, but soon break to pieces. Yields to the file.

No. 1120—PIG IRON. *Labeled "Pig Iron, (Grey, No. 2,) from Suwannee Furnace, &c."*

Finer grained than the preceding, (very fine grained,) and a little darker colored. Appears to be a little harder and tougher than that. Yields to the file.

No. 1121—PIG IRON. *Labeled "White Iron, (No. 4,) from Suwannee Furnace, &c. Refined in the Hearth of the Furnace."*

Very hard, brittle, white iron; presenting a confused bladed crystalline appearance on the fractured surface. About the color of impure nickel.

This was refined by *Kelly's method,* in which Bessemer's process for the purification of iron seems to have been measurably anticipated, viz: by dipping the tuyere into the melted metal in the hearth of the furnace and forcing the cold blast through it.

COMPOSITION OF THESE THREE SAMPLES OF PIG IRON.

	No. 1119. Very grey iron.	No. 1120. Grey iron No. 2.	No. 1121. White iron (refined.)
Iron	92.414	92.560	94.338
Graphite	2.644	2.824	.984*
Combined carbon	2.456	1.876	3.000
Manganese	.201	.273	.129
Silicon	1.950	.863	.375
Slag	.384	.484	none.
Aluminum	.224	.131	.095
Calcium	a trace.	trace.	trace.
Magnesium	.258	.419	.325
Potassium	.096	.086	.102
Sodium	.102	.014	.057
Phosphorus	.192	.321	.387
Sulphur	.100	.149	.152
Loss	--------	--------	.056
Total	101.021	100.000	100.000
Total carbon	5.100	4.700	3.984
Specific gravity	6.9892	6.9238	7.6075

MADISON COUNTY.

No. 1122—CLAY. *Labeled "Potters' Clay, near Waco, used for making Stone-ware, Madison county, Ky."*

Of a yellowish-grey color. Portions colored dark yellowish with oxide of iron. Does not darken much in color on burning. Before

* Although stated as graphite, this was a brownish carbonaceous material.

the blow-pipe it fuses on the edges. Dried at 212° F., it lost 2.86 per cent. of moisture.

COMPOSITION, DRIED AT 212° F.

Silica	62.580
Alumina	21.980
Oxide of iron	4.780
Lime	a trace.
Magnesia	1.276
Brown oxide of manganese	a trace.
Phosphoric acid	not estimated.
Sulphuric acid	.234
Potash	2.607
Soda	.500
Water expelled at a red heat	6.140
	100.097

Its considerable proportion of oxide of iron communicates its peculiar color to the ware made from this clay.

No. 1123—LIMESTONE. *Labeled "Magnesian Limestone; a good building stone; from Mr. Covington's farm, at Elliston, Madison county, Ky., (where the red-bud soil was collected.")*

A dull, dark, buff-grey, fine-granular rock. Powder light grey-buff color. Specific gravity 2.6912.

Dried at 212° F., it lost 0.20 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	49.320
Carbonate of magnesia	30.729
Alumina; and oxides of iron and manganese	2.960
Phosphoric acid	.271
Sulphuric acid	.509
Potash	.374
Soda	.058
Silex and insoluble silicates	14.180
Loss	1.599
	100.000

This deserves trial as a *hydraulic* limestone; although the proportion of silex which it contains is not as great as is found in the best water lime from the Falls of the Ohio.

No. 1124—SHALE. *Labeled "Black Shale, on the flats of Madison county, Ky., where the soil was collected on the slack lands."*

Shale of a dull dark color, nearly black; irregularly laminated. Does not adhere to the tongue. Easily broken. Powder of a dark mouse-color.

Dried at 212° F., it lost 0.90 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	63.120
Alumina, and oxides of iron and manganese	8.560
Carbonate of lime	11.180
Magnesia	2.034
Phosphoric acid	.143
Sulphuric acid	1.653=0.673 sulphur.
Potash	1.363
Soda	
Bituminous matter and water	12.000
	100.053

No. 1125—SOIL. *Labeled "Virgin Soil derived from the Black Devonian Slate; taken from the level tract of land about half way between Elliston and Richmond, Madison county, Ky."*

Dried soil of a light chocolate grey color. Sifted out of it about one third of its weight of iron gravel, or small ferruginous concretions and fragments of soft ferruginous sandstone. (See next number.)

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain and a half of brownish extract, dried at* 212° *F.*, which had the following

COMPOSITION, VIZ:

Organic and volatile matters	0.617
Alumina, and oxides of iron and manganese and phosphates	.080
Carbonate of lime	.497
Magnesia	.133
Sulphuric acid	.018
Potash	.075
Soda	not estimated.
Silica	.245
Loss	.068
Extract, dried at 212° F.	1.733 grains.

The air-dried soil lost 2.450 per cent. of *moisture* at 400° F., and has the following

COMPOSITION:

Organic and volatile matters	6.125
Alumina	2.215
Oxide of iron	11.015
Carbonate of lime	.095
Magnesia	.385
Brown oxide of manganese	not estimated.
Phosphoric acid	.271
Sulphuric acid	not estimated.
Potash	.121
Soda	.039
Sand and insoluble silicates	79.270
Loss	.464
	100.000

This soil contains a large proportion of oxide of iron; but is not remarkably rich. The *iron gravel* contained in it gave the following results, on analysis, viz:

COMPOSITION.

Alumina, and oxides of iron and manganese	53.240
Carbonate of lime	.080
Magnesia	.400
Phosphoric acid	.253
Sulphuric acid	.025
Potash	.066
Soda	.024
Sand and insoluble silicates	36.300
Water, &c., expelled at a red heat	8.600
Loss	1.012
	100.000

No. 1126—Mineral Water. *Labeled "Mineral Water, sent by James H. Spilman, from a bored well eighteen feet deep; used for the steam-engine for ten years; does not fur the boiler. Paint Lick, about twelve miles from Richmond, Madison county, Ky."*

One *thousand parts of the water* was found to contain the following materials, besides free carbonic acid, viz:

COMPOSITION.

Carbonate of lime	0.030	Held in solution by the free carbonic acid.
Carbonate of magnesia	.004	
Carbonate of iron	a trace.	
Phosphate of lime	a trace.	
Chloride of sodium	.456	
Carbonate of soda	.279	
Sulphate of lime	.034	
Sulphate of magnesia	.015	
Sulphate of soda	.030	
Sulphate of potash	.074	
Silica	.044	
	0.966	

or less than one tenth of one per cent. of saline matters.

The small amount of saline matter contained in this water, and the presence of a considerable proportion of carbonate of soda, account for the fact that it forms no crusts in the steam-boiler.

No. 1127—Soil. *Labeled "Virgin, Red-bud Soil, back of Elliston, Madison county, Ky. (New land; produces forty bushels of wheat to the acre.")*

The dried soil is of a dark-umber color. Some fragments of shale were sifted out of it with the coarse seive.

No. 1128—Soil. *Labeled "Red-bud Soil, from an old field forty years in cultivation; now in oats. Back of Elliston, on the slopes below the junction of the Black Devonian Shale and the Magnesian Limestone, Madison county, Ky."*

The dried soil is of an umber color, slightly lighter than the preceding. Some shot iron ore was removed from it by the coarse seive.

No. 1129—SOIL. *Labeled "Sub-soil from the same old field. Back of Elliston, Madison county, Ky."*

The dried soil is of an umber color, slightly lighter than the preceding.

One thousand grains of each of these soils, thoroughly air-dried, were digested severally for a month in water charged with carbonic acid gas, to which they gave up *soluble extract* in the quantities and of the *composition* stated below, viz:

	No. 1127. Virgin soil.	No. 1128. Old field soil.	No. 1129. Sub-soil.
Organic and volatile matters	2.693	0.550	0.560
Alumina, and oxides of iron and manganese and phosphates	.581	.147	.167
Carbonate of lime	4.287	1.903	1.974
Magnesia	.838	.405	.420
Sulphuric acid	.050	.028	.059
Potash	.208	.033	.035
Soda	.090	.037	.050
Silica	.516	.367	.367
Loss	.287	.130	.131
Soluble extract, dried at 212° F., (grains)	9.550	3.600	3.743

Dried at 400° F., the *composition* of these soils was found to be as follows:

	No. 1127. Virgin soil.	No. 1128. Old field soil.	No. 1129. Sub-soil.
Organic and volatile matters	15.450	8.508	7.584
Alumina	3.565	6.240	5.900
Oxide of iron	5.560	6.835	6.360
Carbonate of lime	1.295	.470	.770
Magnesia	.750	1.041	.960
Brown oxide of manganese	.270	.245	.320
Phosphoric acid	.252	.214	.199
Sulphuric acid	.120	.059	.085
Potash	.753	.796	.705
Soda	.123	.097	.231
Sand and insoluble silicates	71.045	75.620	76.745
Loss	.817	----------	.135
Total	100.000	100.125	100.000
Moisture, expelled at 400° F., (per cent.)	6.150	4.035	4.535

These very rich soils are remarkable for the large proportions of organic matters, lime, potash, phosphoric and sulphuric acids, which they contain, as well as for the large amount of soluble silica which

they give up to the carbonated water. It will be seen that the soil of the old field shows the usual signs of deterioration, except in the relative proportion of its potash, whilst it approximates somewhat to the nature of the sub-soil; probably through the influence of the plow. This resemblance may be more particularly noticed in the amount and composition of the *soluble extract* withdrawn by the water charged with carbonic acid; which will be seen to be much less in proportion, from the soil of the old field and from the sub-soil, than from the virgin soil; which latter gives up a remarkably large quantity. These soils, if well drained, ought to be very productive and durable. Doubtless, much of the *organic matter* contained in them, which gives them their dark color, as well as the large proportion of potash, were derived from the black slate from which they originate.

MASON COUNTY.

No. 1130—Marl. *Labeled "Earthy portion, between the D. Lynx beds of the upper blue limestone, edge of Mason and Fleming counties, Ky."*

A fine grained, dark-greenish-grey rock. Not adhering to the tongue. Dried at 212° F., it lost 0.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	78.180
Alumina, and oxides of iron and manganese	8.020
Carbonate of lime	7.380
Magnesia	3.105
Phosphoric acid	1.040
Sulphuric acid	.592
Potash	.722
Soda	.170
Water and loss	.791
	100.000

Might be used with advantage on exhausted land.

No. 1131—Limestone. *Labeled "Oxidated part, near the surface of the D. Lynx beds of the blue limestone, edge of Mason and Fleming counties, Ky."*

Almost made up of fossil *Delthyris Lynx* and branching *Chaetetes.*

No. 1132—Limestone. *Labeled "Limestone from the Mason county tobacco land, where the soil was collected for analysis."*

A dark, bluish-grey limestone; with buff-grey and brownish oxidated portions; containing shells of *Delthyris Lynx* and *Chaetetes.* Lower Silurian.

No. 1133—LIMESTONE. *Labeled "Delthyris Lynx beds of the upper part of the blue limestone; (Lower Silurian;) near the edge of Mason and Fleming county, Ky.; which give character to the soil of the southern part of Mason and the northern part of Fleming counties, where soils were collected for analysis."*

A dark, olive-grey rock, full of shells of *Delthyris Lynx* and fragments of *Chaetetes*. Appears to be pyritiferous.

The *composition* of these three limestones is as follows, dried at 212° F.:

	No. 1131. D. Lynx limestone.	No. 1132. Tobac.land limestone.	No. 1133. D. Lynx limestone.
Carbonate of lime	75.440	87.980	77.360
Carbonate of magnesia	4.783	1.721	2.307
Alumina and oxides of iron and manganese	3.751	2.200	3.910
Phosphoric acid	.409	.348	.310
Sulphuric acid	.474	.372	*2.433
Potash	.540	.289	.424
Soda	.292	.047	.068
Silex and insoluble silicates	14.440	6.380	13.980
Loss	----------	.663	.666
Total	100.129	100.000	101.458
Moisture, lost at 212° F., per cent.	0.400	0.200	0.300

These limestones are more rich than usual in the mineral elements conducive to vegetable growth.

No. 1134—SOIL. *Labeled "Mason County Virgin Tobacco Soil; from the hill-side near Dover; about one hundred and fifty feet above the Ohio river, in the midst of the Blue Limestone. (Lower Silurian.) Growth, sugar tree, walnut, black and white ash, buckeye, &c."*

Dried soil of a dirty-buff or light-umber color.

No. 1135—SOIL. *Labeled "Soil six or seven years in cultivation: fourth year in tobacco it failed: is exhausted of some ingredient essential to tobacco, but produces fine wheat. Had a top-dressing of nitre two years ago. Langhorne Tabb's land, near foot of hill-side near Dover, Mason county, Ky. What has it lost?"*

Color a shade lighter than that of the preceding.

* Equal to 0.975 per cent. of *sulphur*, in which form it mostly exists in this limestone, combined with iron, as sulphuret of iron, or iron pyrites; and hence the apparent excess in the sum of the analysis.

No. 1136—SOIL. *Labeled "Sub-soil from the same field, on Langhorne Tabb's land, near Dover, Mason county, Ky."*

Color of the dried soil lighter than that of the preceding.

One thousand grains of each of these soils, thoroughly air-dried, were digested severally for a month in water charged with carbonic acid gas; to which they gave up soluble matters in quantity and composition as represented in the following table, viz:

	No. 1134. Virgin soil.	No. 1135. Exhausted soil.	No. 1136. Sub-soil.
Organic and volatile matters	1.416	1.030	0.750
Alumina, and oxides of iron and manganese and phosphates	.130	.230	.147
Carbonate of lime	2.163	1.930	1.780
Magnesia	.294	.242	.123
Sulphuric acid	.074	.077	.045
Potash	.106	.077	.081
Soda	.026	.013	trace.
Silex and insoluble silicates	.314	.147	.146
Loss	.047	----------	.265
Soluble extract, dried at 212° F., (grains)	4.570	3.746	3.337

Dried at 400° F., the *composition* of these soils is as follows:

	No. 1134. Virgin soil.	No. 1135. Exhausted soil.	No. 1136. Sub-soil.
Organic and volatile matters	8.462	6.445	5.931
Alumina	4.745	3.730	4.395
Oxide of iron	6.240	4.465	4.090
Carbonate of lime	.836	.476	.497
Magnesia	.798	.807	.618
Brown oxide of manganese	.146	.221	.196
Phosphoric acid	.231	.212	.245
Sulphuric acid	.084	.042	.059
Potash	.558	.418	.475
Soda	.160	.023	.079
Sand and insoluble silicates	78.100	83 330	83.130
Loss	----------	----------	.285
Total	100.360	100.169	100.009
Moisture, lost at 400° F., (per cent.)	4.175	3.265	3.050

Under the head of Bracken county the analyses of other tobacco soils may be seen, and there, as well as in the appendix, may be found remarks on the cultivation of this plant, and its influence on the soil, &c., &c.

This soil does not yield as much *soluble matter*, to water containing carbonic acid, as the virgin soil from Bracken county, and probably failed to produce tobacco profitably, after a few years, not because it was really exhausted, but because it did not yield its nourishment *fast enough* for the rapid growth of that very exacting plant. The soil which is said to be exhausted is yet quite rich in the mineral elements of plants, and could be made to produce tobacco again, by setting it well in clover, and then plowing it in, after having used it for pasture for a year or two. To cut the clover and remove the hay would not answer as good a purpose. It might be still further improved by using stable manure abundantly on the land, especially with lime and plaster of paris and wood ashes, at the time of sowing the clover, or during its early growth. By these means, when, after plowing in the clover, all the vegetable matter has become fully decomposed, a large amount of soluble materials of the proper kind will be present for the nourishment of the tobacco crop.

MEADE COUNTY.

No. 1137—HYDRAULIC LIMESTONE. *Labeled "Limestone from Mitchell's Spring, Meade county, Ky. Cliff about* 300 *feet above the Ohio river." (Analyzed for Mr. James Anderson, of Louisville.)*

Rock of a dull dirty-buff-grey color. Adheres to the tongue.

No. 1138—HYDRAULIC LIMESTONE? *(Sent by the same person for analysis; (from the branch at the foot of cliff near Rock Haven, Meade county, Ky."*

Rock of a dull, dark-grey color; not adhering to the tongue.

COMPOSITION OF THESE TWO LIMESTONES, DRIED AT 212° F.

	No. 1137.	No. 1138.
Carbonate of lime	47.560 (a)	28.360 (b)
Carbonate of magnesia	26.515 (c)	17.771 (d)
Alumina, and oxides of iron and manganese and phosphates	2.160	2.680
Sulphuric acid	1.332	2.707
Potash	.126	.115
Soda	.265	.116
Sand and insoluble silicates	19.680	47.980
Loss	2.362	.271
	100.000	100.000

(*a*) Equal to 26.688 per cent. of *lime*
(*b*) Equal to 12.631 per cent. of *magnesia.*
(*c*) Equal to 15.974 per cent. of *lime.*
(*d*) Equal to 8.466 per cent. of *magnesia.*

The first of these, No. 1137, will, very probably, make good hydraulic cement, if properly calcined and managed. The second may possibly contain too much siliceous matter; but is worthy of careful trial.

MERCER COUNTY.

No. 1139—SOIL. *Labeled "Virgin Soil, from woodland, on the farm of James C. McAfee, on the east side of Salt river, four miles north of Harrodsburg, on the base line. Forest growth, sugar-tree, black walnut, oak, black ash, cherry, and hickory. Set in blue-grass: no under-growth. Lower Silurian formation."*

Dried soil of a light chocolate brown color.

No. 1140—SOIL. *Labeled "Sub-soil of the preceding."*

Dried sub-soil of a dirty-buff color.

No. 1141—SOIL. *Labeled "Soil from an old field cultivated in hemp for eight succeeding years, then changed to corn, wheat, rye, corn, and now in barley: the rye was fed down with hogs. Farm of James C. McAfee, Mercer county, Ky." (As above)*

Dried soil of a light grey-brown color, lighter than that of the virgin soil. Some shot iron-ore (small rounded ferruginous concretions) were sifted out of it with the coarse seive.

No. 1142—SOIL. *Labeled "Sub-soil of the preceding, &c., &c." (These soils were collected by Mr. S. S. Lyon.)*

Dried sub-soil of a dirty buff color. Some shot iron ore was sifted out of it; not as much as from the preceding.

One thousand grains of each of these four specimens of soil, were digested for a month in water charged, under pressure, with carbonic acid. The soluble materials extracted from them severally may be tabulated as follows, viz:

	No. 1139. Virgin soil.	No. 1140. Sub-soil.	No. 1141. Old soil.	No. 1142. Sub-soil.
Organic and volatile matters	3.673	0.333	0.800	0.385
Alumina, and oxides of iron and manganese and phosphates	.147	.063	.163	.080
Carbonate of lime	2.697	.230	1.197	.263
Magnesia	.100	.090	.094	.555
Sulphuric acid	.032	.022	.033	.028
Potash	.069	.012	.090	.061
Soda	.011	.011	.046	.028
Silica	.081	.043	.131	.147
Loss	----------	----------	.096	----------
Soluble extract, dried at 212° F., (grains)	6.810	0.804	2.650	1.547

The *composition* of these four soils, dried at 400° F., was found to be as follows, viz:

	No. 1139. Virgin soil.	No. 1140. Sub-soil.	No. 1141. Old soil.	No. 1142. Sub-soil.
Organic and volatile matters	5.564	3.413	4.805	3.289
Alumina	5.090	6.715	4.595	5.840
Oxide of iron	4.115	4.990	4.740	5.115
Carbonate of lime	.495	.245	.320	.220
Magnesia	.732	.828	.811	.887
Brown oxide of manganese	.120	.120	.120	.220
Phosphoric acid	.323	.243	.288	.345
Sulphuric acid	not estim'd	not estim'd	.042	not estim'd
Potash	.366	.420	.140	.290
Soda	.143	.019	.108	.035
Sand and insoluble silicates	83.295	82.695	83.625	83.945
Loss	----------	.312	.406	----------
Total	100.243	100.000	100.000	100.186
Moisture, lost at 400° F., (per cent.)	4.300	4.000	3.750	3.150

The effect of cultivation may be observed in the composition of the soil of the *old field,* as compared with that of the *virgin soil,* in the reduced proportions of *organic and volatile matters, carbonate of lime, phosphoric acid, potash, and soda,* and in its small quantity of *hygroscopic moisture.* The sub-soil seems to be richer than the surface soil.

No. 1143—LIMESTONE. *Labeled "Limestone from the farm of James C. McAfee, Mercer county, &c. Comes to the surface about three hundred yards from where the samples of Virgin Soil and Sub-soil were collected."* (*Procured by S. S. Lyon, Esq.*)

A compact, light-grey, fossiliferous limestone; weathered surfaces of a dirty-buff color. (*Lower Silurian. Blue Limestone.*)

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	90.720
Carbonate of magnesia	4.615
Alumina, and oxides of iron and manganese	2.700
Phosphoric acid	.146
Sulphuric acid	not estimated
Potash	.328
Soda	.021
Insoluble silicates	1.880
	100.410

No. 1144—SOIL. *Labeled "Virgin Soil from the farm of Mr. Vandevere; three miles west of Harrodsburg, in the oak region of Mercer county, Ky."* (*Collected by S. S. Lyon, Esq.*)

Dried soil of a dirty-grey-buff color.

No. 1145—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Dried sub-soil more buff and slightly darker than the preceding.

No. 1146—SOIL. *Labeled "Soil from an old field; farm of Mr. Vandevere, Mercer county, &c., &c."*

Dried soil of a dirty-grey-buff color.

No. 1147—SOIL. *Labeled "Sub-soil of the old field, &c., &c."*

Dried soil slightly darker and more buff colored than the preceding.

Digested for a month in water charged with carbonic acid, these soils gave *soluble materials* as represented in the following table, viz:

	No. 1144. Virgin soil.	No. 1145. Sub-soil.	No. 1146. Old soil.	No. 1147. Sub-soil.
Organic and volatile matters	1.083	0.960	1.330	0.323
Alumina, and oxides of iron and manganese and phosphates	.281	.147	.213	.140
Carbonate of lime	1.053	.940	.947	.480
Magnesia	.080	.089	.088	.055
Sulphuric acid	.062	.022	.067	.044
Potash	.045	.052	.054	.029
Soda	.103	.133	.070	.276
Silica	.081	.098	.097	.114
Loss	----------	.009	.224	.196
Watery extract, dried at 212° F., (grains)	2.788	2.450	3.090	1.757

The *composition* of these four samples of soils, dried at 400° F., was found, by analysis, to be as follows:

	No. 1144. Virgin soil.	No. 1145. Sub-soil.	No. 1146. Old field.	No. 1147. Sub-soil.
Organic and volatile matters	5.703	5.707	5.049	6.747
Alumina	3.015	5.665	3.240	14.360
Oxide of iron	3.210	4.100	3.710	
Carbonate of lime	.345	.420	.320	.360
Magnesia	.512	.553	.612	.460
Brown oxide of manganese	.070	.240	.245	----------
Phosphoric acid	.096	.096	.128	.138
Sulphuric acid	.028	.016	.024	.042
Potash	.172	.183	.203	.237
Soda	.068	.015	.108	.057
Sand and insoluble silicates	86.570	82.660	86.145	77.570
Loss	.211	.345	.216	.029
Total	100.000	100.000	100.000	100.000
Moisture, lost at 400° F., (per cent.)	2.600	3.115	2.450	5.525

For some reason, unexplained, the soil of the old field appears to be somewhat richer than the virgin soil. If no mistake has been made in the collection and labeling of these soils, it would appear that there was an original difference in these soils; that which has been cultivated having been the richer.

MONTGOMERY COUNTY.

No. 1148—SOIL. *Labeled "Soil, first year in cultivation, (in corn,) from the farm of Mr. R. Apperson, Mount Sterling, Montgomery county, Ky. On the Delthyris Lynx beds of the Lower Silurian blue limestone. Forest growth, black walnut, sugar tree, &c. Excellent corn land. Produces hemp, but not well."*

Dried soil of a light yellowish-umber color.

No. 1149—SOIL. *Labeled "Same Soil, from an old field, thirty to forty years in cultivation. Mr. R. Apperson's farm, Mt. Sterling, Montgomery county, Ky."*

Dried soil slightly darker colored than the preceding.

No. 1150—SOIL. *Labeled "Sub-soil from Mr. Apperson's farm; (garden adjoining the old field,) Mt. Sterling, Montgomery county, Ky."*

Dried sub-soil lighter colored and more yellowish than the preceding.

No. 1151—SOIL. *Labeled "Red under-clay of Montgomery county, two miles south of Mt. Sterling."*

Dried clay of a light brick-red color.

(These soils were collected by Dr. D. D. Owen.)

One thousand grains of each of these four soils, thoroughly air-dried, were digested severally in water charged with carbonic acid, for about a month. The quantity of soluble materials extracted is tabulated as follows:

	No. 1148. Virgin soil.	No. 1149. Soil of old field.	No. 1150. Sub-soil.	No. 1151. Under-clay.
Organic and volatile matters	1.733	0.666	0.333	0.266
Alumina, and oxides of iron and manganese and phosphates	.381	.131	.081	.048
Carbonate of lime	1.927	1.113	.580	.263
Magnesia	.227	.178	.106	.042
Sulphuric acid	.054	.0[illegible]8	.046	.022
Potash	.086	.052	.029	.022
Soda	.095	.026	.032	.022
Silica	.200	.200	.200	.214
Loss	.373	.041	----------	----------
Watery extract, dried at 212° F., (grains)	5.076	2.435	1.407	0.899

The *composition* of these four specimens of soil from Montgomery county, was found by analysis to be as follows, viz:

	No. 1148. Virgin soil.	No. 1149. Old field.	No. 1150. Sub-soil.	No. 1151. Under-clay
Organic and volatile matters	6.751	6.172	4.171	4.378
Alumina	4 690	5.440	6.590	7.400
Oxide of iron	5.810	4.710	6.235	11.100
Carbonate of lime	.420	.420	.220	.095
Magnesia	.677	.583	.634	.235
Brown oxide of manganese	.245	.120	.295	.495
Phosphoric acid	.313	.345	.257	.395
Sulphuric acid	.076	.067	.041	.024
Potash	.410	.331	.372	.280
Soda	.245	.133	.139	.104
Sand and insoluble silicates	80.095	81.470	81.370	72.670
Loss	.268	.209	----------	2.824
Total	100.000	100.000	100.324	100.000
Moisture, lost at 400° F, (per cent.)	3.725	3.600	2.900	3.525

These are very good soils; but the under-clay does not prove to be as rich in *potash* as it usually is when found resting on the blue limestone.

No. 1152—CARBONATE OF IRON. "*From James Wells' place, Montgomery county, Ky.* (*Clinton Group.*") (*Collected by Messrs. Downie and Lesquereux.*)

Exterior of the irregular nodule coated in part with thin layers of dense dark-brown *limonite;* under which is a softer ochreous-brownish coating. *Interior portion* is dark grey, dense, and fine-grained carbonate of iron. Portion of an encrinital stem in one part.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	46.171	=35.254 per cent. of iron.
Oxide of iron	18.489	
Alumina	2.160	
Carbonate of lime	6.950	
Carbonate of magnesia	4.936	
Carbonate of manganese	1.626	
Phosphoric acid	.630	
Sulphuric acid	.647	
Potash	.366	
Soda	.170	
Silex and insoluble silicates	17.480	
Water and loss	.375	
	100.000	

A good iron ore.

No. 1153—COAL. *Labeled "Bituminous Coal: three miles southeast of Jas. Wells', fifteen miles east of Mt. Sterling, Montgomery county, Ky. Thirty feet under conglomerate. Bed about twenty-two inches thick." (Obtained by Messrs. Downie and Lesquereux.)*

Coal cleaving in thin layers, with soft fibrous coal between; no appearance of pyrites; but the weathered surfaces are soiled with ochreous oxide of iron. Over the spirit lamp it swelled up and agglutinated, leaving a spongy coke. Specific gravity, 1.264.

PROXIMATE ANALYSIS.

Moisture	2.70	Total volatile matters	41.30
Volatile combustible matters	38.60		
Fixed carbon (in the coke)	55.80	Light coke	58.70
Salmon colored ashes	2.90		
	100.00		100.00

The percentage of *sulphur* was found to be 1.072.

The *composition of the ash* is as follows:

Silica	0.884
Alumina, and oxides of iron and manganese	1.720
Lime	.215
Magnesia	.200
Phosphoric acid	trace.
Sulphuric acid	.014
Alkalies	traces
	3.033

No. 1154—COAL. *Labeled "Coal from 'Cabin Bank,' (owned by Jas. Wells,) on the head waters of Hawkins' branch of Slate creek, (Station 800, T. line Eastern div. of Survey,) Montgomery county, Ky. (Under coarse sandstone, like millstone grit.") Obtained by Jos. Lesley, jr.*

A pure, deep pitch-black, shining coal, with some fibrous coal between the layers. Over the spirit lamp it softened and agglutinated somewhat, and swelled into a moderately dense coke. Specific gravity 1.270.

PROXIMATE ANALYSIS.

Moisture	3.60	Total volatile matters	41.60
Volatile combustible matters	38.00		
Fixed carbon in the coke	55.40	Moderately dense coke	58.40
Purplish-grey ashes	3.00		
	100.00		100.00

The percentage of *sulphur* is 1.21.

COMPOSITION OF THE ASH.

Silica	0.884
Alumina, and oxides of iron and manganese	1.380
Lime	trace.
Magnesia	.233
Sulphuric acid, alkalies, and loss	.503
	3.000

This coal remarkably resembles the preceding in composition and properties, and probably is from the same bed.

MORGAN COUNTY.

No. 1155—CARBONATE OF IRON. *Labeled "Carbonate of Iron with Sulphuret of Zinc; in the shale at the base of the coal measures of Caney creek, Morgan county, Ky."*

A rounded nodule. Exterior, reddish-brown; interior portion dark-brown: the fissures infiltrated with zinc blende and a whitish powdery mineral. Powder of a light yellowish-brown color. A mixed portion, without the sulphuret of zinc, taken for analysis.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	48.620	=36.472 per cent. of iron.
Oxide of iron	16.650	
Alumina	1.920	
Carbonate of lime	1.480	
Carbonate of magnesia	6.360	
Carbonate of manganese	.722	
Phosphoric acid	.505	
Sulphuric acid	.517	
Potash	.568	
Soda	.000	
Silex and insoluble silicates	17.580	
Water and loss	5.078	
	100.000	

The air-dried powder lost 1.1 per cent. of *moisture* at 212° F.

The proportion of sulphuret of zinc being variable in different specimens, it was excluded from the analysis. This is a *sufficiently rich ore of iron.*

No. 1156—SOIL. *Labeled "Virgin Soil from the coal measures of Caney creek of Licking river, Morgan county, Ky. Forest growth, white oak, beech, sugar-tree, and black walnut."*

Dried soil of a light yellowish umber color. It contains some minute scales of mica and fragments of soft ferruginous sandstone.

No. 1157—SOIL. *Labeled "Soil from an old field, forty-two years in cultivation, from Judge W. Lykins' farm, head waters of Caney creek. Coal measures. Morgan county, Ky."*

Dried soil resembles the preceding. Contains some fragments of ferruginous sandstone.

(These soils were collected by Dr. Owen.)

One thousand grains of each of these soils, digested for a month in water charged with carbonic acid under pressure, gave up soluble materials as represented below, viz:

	No. 1156. Virgin soil.	No. 1157. Old field.
Organic and volatile matters	1.150	0.400
Alumina, and oxides of iron and manganese and phosphates	.237	.131
Carbonate of lime	1.180	.296
Magnesia	.191	.077
Sulphuric acid	.053	.038
Potash	.069	.083
Soda	.059	trace.
Silica	.047	.047
Loss	.347	.161
Soluble extract, dried at 212° F., (grains)	3.333	1.233

The composition of these two soils, dried at 400° F., was found to be as follows, viz:

	No. 1156. Virgin soil.	No. 1157. Soil of old field.
Organic and volatile matters	7.243	4.881
Alumina	3.590	3.415
Oxide of iron	3.260	2.710
Carbonate of lime	.320	.145
Magnesia	.489	.385
Brown oxide of manganese	.195	.070
Phosphoric acid	.204	.192
Sulphuric acid	.067	.050
Potash	.372	.232
Soda	trace.	.018
Sand and insoluble silicates	84.360	88.595
Total	100.100	100.693
Moisture, lost at 400° F., (per cent.)	2.325	1.550

The usual diminution of the *soluble* and *essential* ingredients of the soil is to be observed in the analysis of that of the old field as compared with the virgin soil.

No. 1158—CARBONATE OF IRON; *from a layer eighteen inches thick on the land of Silas Bishop, on Red River, six miles south of Hazlegreen, Morgan county, Ky.* (*Brought by C. C. Moxley.*")

A dense, fine-grained carbonate, of a dark-grey color, sparkling with minute scales of mica. Weathered surface brownish-red and yellow.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	55.382	=28.521 per cent. of iron
Oxide of iron	2.234	
Alumina	.380	
Carbonate of lime	1.684	
Carbonate of magnesia	2.274	
Carbonate of manganese	1.776	
Phosphoric acid	.335	
Sulphuric acid	.269	
Potash	.232	
Soda	.177	
Silex and insoluble silicates	31.880	
Bituminous matters and loss	3.377	
	100.000	

A good iron ore, rich enough to be profitably smelted.

No. 1159—NATIVE ALUM. *A saline efflorescence labeled "Alum? from micaceous grey-blue shales under bituminous coal. Three and a half miles from West Liberty, on the Hazlegreen road, Morgan county, Ky."* (*Collected by Messrs. Downie and Lesquereux.*)

A whitish saline matter of an acid astringent taste, mixed with fragments of shale. Soluble with little residue in water. Was found, on testing, to be principally sulphate of alumina with small quantities of chloride, oxide of iron, &c.

If in sufficient quantity, could be employed in the manufacture of alum, by the addition of potash salt, &c., &c.

No. 1160—COAL. *Labeled "Coal, from a bed sixteen inches thick. Casby's bank, a quarter of a mile from his house, on the Little Sandy road, and on the Lick Fork of Elk branch, Morgan county Ky."*) (Station 1741, base line.) Obtained by Joseph Lesley, jr.

A pure deep, pitch-black moderately firm, shining coal; little or no fibrous coal between the layers. Thin scales of bright iron pyrites in some of the joints. Over the spirit lamp it softened a little and left a dense coke. Specific gravity 1.253.

PROXIMATE ANALYSIS.

Moisture	4.40	Total volatile matters	39.20
Volatile combustible matters	34.80		
Fixed carbon in the coke	60.06	Pretty dense coke	60.80
Buff-grey ashes	.74		
	100.00		100.00

The percentage of *sulphur* was found to be 0.672.

No. 1161—COAL. *Labeled "Coal from an opening made some time since, on Big Branch of Lick Fork of Elk branch of Licking river, Morgan county, Ky.* (Station 1690, base line.") Obtained by Jos. Lesley, jr.

A shining deep pitch-black coal: cleaving with irregular shining surfaces: not much fibrous coal. Over the spirit lamp it softens and swells somewhat, leaving a moderately dense coke. Specific gravity 1.250.

PROXIMATE ANALYSIS.

Moisture	3.34	Total volatile matters	44.60
Volatile combustible matters	41.26		
Fixed carbon (in the coke)	54.06	Moderately dense coke	55.40
Light-grey-buff ashes	1.34		
	100.00		100.00

The percentage of *sulphur* was found to be 0.87.

MUHLENBURG COUNTY.

No. 1162—LIMONITE. *Labeled "Hoskins' Ore, lower bed. Muddy River, Muhlenburg county, Ky.* (*Coal measures.*")

A dense, dark-brown limonite, in irregular layers, inclosing cavities lined with ochreous ore. Powder of a yellowish-brown color.

Dried at 212° F., it lost 1.55 per cent. of moisture, and has the following

COMPOSITION:

Oxide of iron	67.340=47.159 per cent. of iron.
Alumina	1.000
Carbonate of lime	trace.
Magnesia	.615
Brown oxide of manganese	.240
Phosphoric acid	1.591
Sulphuric acid	.680
Potash	.154
Soda	.106
Silex and insolubie silicates	16.980
Combined water	11.300
	100.006

Quite a rich iron ore, and but for the considerable proportion of phosphoric acid which it contains, would be unobjectionable. This would

tend to diminish the toughness of the iron made from it; which tendency might be diminished, however, by the addition of a pure aluminous material, (pure clay,) with an excess of lime for the flux.

No. 1163—Coal. *Labeled "McNairy's seven feet Coal, working bed. Limestone roof. Elwood, Muhlenburg county, Ky."*

A shining, moderately firm, pitch-black coal; iridescent on the surfaces of the joints. Fibrous coal between some of the layers; others presenting an irregular shining surface. Over the spirit lamp it swelled up and agglutinated into a light, cellular coke, giving out much flame. Specific gravity, 1.287

PROXIMATE ANALYSIS.

Moisture	3.30	Total volatile matters	41.10
Volatile combustible matters	37.80		
Fixed carbon (in the coke)	56.10	Light coke	58.90
Grey ashes	2.80		
	100.00		100.00

The percentage of *sulphur* was found to be 2.711; which is considerable.

No. 1164—Coal. *Labeled "Upper Coal at Airdrie, used for making iron, Muhlenburg county, Ky."*

A deep pitch-black coal, rather brittle; some fibrous coal between the layers, and a thin white incrustation (of sulphate of lime) in some of the joints. Over the spirit lamp it swells up into a moderately dense coke. Specific gravity, 1.593.

PROXIMATE ANALYSIS.

Moisture	7.06	Total volatile matters	37.90
Volatile combustible matters	30.84		
Fixed carbon (in the coke)	58.70	Moderately dense coke	62.10
Light-grey ashes	3.40		
	100.00		100.00

The percentage of *sulphur* was found to be 0.879.

COMPOSITION OF THE ASH.

Silica	2.284
Alumina, and oxides of iron and manganese	.780
Lime	trace.
Magnesia	.233
Sulphuric acid	.063
Potash	.189
Soda	.135
	3.684

NELSON COUNTY.

No. 1165—LIMESTONE. *Labeled "Hydraulic Limestone, Bardstown, Nelson county, Ky."*

A greenish-grey, dull, fine-granular limestone.

No. 1166—LIMESTONE. *Labeled "Magnesian Limestone, Rolling Fork, Nelson county, Ky. Upper Silurian formation."*

A light-grey, dull, fine-granular limestone, with small pores or cavities. Weathered surfaces of a dirty grey-buff color.

No. 1167—LIMESTONE, (*two specimens, a and b.*) *Labeled "Mr. Troutman's Building Stone, Nelson county, Ky. Upper Silurian formation."*

A grey-buff, dull, fine-granular limestone.

COMPOSITION OF THESE FOUR LIMESTONES, DRIED AT 212° F.

	No. 1165. Bardstown.	No. 1166 (a.) Rolling Fork.	No. 1166 (b.) Rolling Fork.	No. 1167. Troutman's
Carbonate of lime	40.480	49.780	48.980	50.480
Carbonate of magnesia	24.267	34.456	34.100	38.154
Alumina, and oxides of iron and manganese	4.493	3.000	2.980	2.100
Phosphoric acid	.207	.246	.118	.118
Sulphuric acid	.819	.475	.386	.289
Potash	.455	.270	not estimated	.258
Soda	.042	.006		.260
Silex and insoluble silicates	29.380	10.780	11.480	8.380
Loss	----------	.987	1.956	----------
	100.143	100.000	100.000	100.039
Moisture, lost at 212° F., (per cent.)	0.44	0.40	0.20	0.20

All of these limestones will most probably be found to make good hydraulic cement when properly calcined and prepared; except perhaps the last one, Troutman's building stone, which does not appear to contain the proper quantity of silicious matter. But even this deserves trial in this relation, as very good water cement has been made of magnesian lime rocks containing as little silex as this. It is probable that a considerable proportion of *potash* aids in the formation of the silicates which are essential to the hydraulic property. These hydraulic porous limestones are not generally good building stones; as was exemplified in the building of the court-house, at Louisville, in which this kind of rock has undergone rapid disintegration, by scaling, under the influence of the atmospheric agencies.

No. 1168—Fossil Coral. *Labeled "Favestella stellata. (Hall.) Junction of Upper and Lower Silurian formations, Bardstown, Nelson county, Ky. (Lower Silurian formation.")*

An irregularly rounded mass of the fossil coral: the cells completely filled with nearly white carbonate of lime.

Dried at 212°, the powder gave off 0.3 per cent. of moisture.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	94.380
Carbonate of magnesia	2.419
Alumina, and oxides of iron and manganese	.660
Phosphoric acid	.117
Sulphuric acid	.338
Potash	.193
Soda	.000
Silex and insoluble silicates	1.980
	100.087

Quite a pure carbonate of lime, which would burn into a very white lime.

No. 1169—Soil. *Labeled "Virgin Soil, from woodland, on the farm of Mr. Felix G. Murphy; on ridge land between the waters of Mill and Stuart's creeks; north side of Beech Fork of Salt river. About forty to forty-five feet below the level of the Black Slate. Forest growth, beech, sugar-tree, large white and yellow poplar, black walnut, hickory, white ash, mulberry, paw-paw, dogwood. Yellow (Upper) Silurian rocks. Nelson county, Ky." (Collected by S. S. Lyon, Esq.)*

Dried soil of a light reddish-brown color.

No. 1170—Soil. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil much lighter than the preceding; of a reddish buff-color.

No. 1171—Soil. *Labeled "Soil on Felix G. Murphy's farm, &c., forty feet below the level of the two preceding specimens. Some flints of sub-carboniferous or Devonian origin thrown out of the hole where the specimen was taken, Nelson county, Ky."*

Dried soil of a light reddish-brown color. Some irregular fragments of porous, decayed chert, reddish ferruginous sandstone and shot iron ore were sifted out of this and the succeeding sub-soil with the coarse seive.

No. 1172—Soil. *Labeled "Sub-soil of the next preceding. Felix G. Murphy's farm, &c., &c."*

Dried soil of a lighter reddish-brown color than the preceding.

No. 1173—Soil. *Labeled "Under-clay. Thirty feet below the level of the two preceding specimens: from five feet below the surface, on a root wad. Felix G. Murphy's farm, Nelson county, Ky."*

Fragments of porous, friable, magnesian limestone, full of encrinital stems, &c., were found in this specimen; the analysis of which is given below.

No. 1174—Soil. *Labeled "Soil from an old field, now in pasture; on Felix G. Murphy's farm, Nelson county, Ky."*

Portions of magnesian limestone, (see analysis below,) were found in this and the succeeding sub-soil, with some cherty and ferruginous fragments. Dried soil of a dirty, light reddish-brown color.

No. 1175—Soil. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil a little lighter colored than the soil preceding.

One thousand grains of each of these soils, digested as before described in water charged with carbonic acid, gave up the following materials, viz:

	No. 1169. Soil.	No. 1170. Sub-soil.	No. 1171. Soil.	No. 1172. Sub-soil.	No. 1173. Under-clay.	No. 1174. Old field.	No. 1175. Sub-soil.
Organic & volatile matters	2.300	0.496	1.410	0.380	1.600	0.350	0.300
Alumina, & oxides of iron & manganese & phosphates	.347	.080	.100	.080	.080	.130	.163
Carbonate of lime	1.680	.263	1.680	.913	2.180	.974	.747
Magnesia	.517	.250	.301	.283	.107	.216	.183
Sulphuric acid	.062	.060	.053	.022	.079	.038	.011
Potash	.289	.091	.140	.080	.056	.096	.062
Soda	.045	.026	trace.	.023	.072	.039	.095
Silica	.374	.194	.100	.146	.031	.162	.200
Loss (water & carbonic acid)	.041	--------	.756	.173	1.095	.112	.072
Watery extract, dried at 212° F., (grains)	5.655	1.460	4.540	2.100	5.300	2.117	1.833

The *composition* of these seven soils was found, by analysis, to be as follows, dried at 400° F.:

	No. 1169. Soil.	No. 1170. Sub-soil.	No. 1171. Soil.	No. 1172. Sub-soil	No. 1173. Under-clay.	No. 1174. Old field.	No. 1175. Sub-soil.
Organic & volatile matters	7.351	2.982	7.563	5.812	9.975	4.836	4.665
Alumina	4.990	6.125	4.850	6.640	8.740	4.330	6.990
Oxide of iron	4.015	4.925	5.425	6.415	12.675	3.865	6.415
Carbonate of lime	.171	.045	.411	.311	3.221	.270	.196
Magnesia	.691	.637	.702	.692	2.878	.455	.983
Brown oxide of manganese	.495	.420	.720	.870	.620	.324	.145
Phosphoric acid	.331	.145	.272	.142	.149	.144	.113
Sulphuric acid	.064	.033	.036	.050	.041	.065	.040
Potash	.352	.381	.452	.349	.348	.280	.410
Soda	.017	.032	.040	.049	.297	062	.139
Sand and insoluble silicates	82.395	83.470	79.295	78.795	61.095	85.895	80.495
Loss		.805	.234				
Total	100.872	100.000	100.000	100.125	100.039	100.526	100.591
Moisture, lost at 400° F., (per cent.)	3.210	2.100	3.610	3.225	4.875	2.300	3.225

These may be classed amongst our best soils. The under-clay does not exhibit as much richness in potash and phosphoric acid as might have been expected; but its proportion of carbonate of lime is large.

The soil of the old field shows a smaller quantity of potash than any of the soils. The sub-soils do not appear to be richer than the surface soils.

No. 1176—LIMESTONE. *Labeled "Porous Magnesian Limestone found in the under-clay, (No.* 1173,) *on Felix G. Murphy's land, Nelson county, Ky. Upper Silurian."*

A friable dull grey rock; exhibiting numerous fragments of encrinital stems on its degraded surfaces. Powder of a light buff color.

No. 1177—LIMESTONE. *Labeled "Yellow Magnesian Limestone; found in soil No.* 1174, *on Felix G. Murphy's farm, Nelson county, Ky."* Powder of a light-buff color.

COMPOSITION OF THESE TWO LIMESTONES, DRIED AT 212° F.

	No. 1176. From under-clay.	No. 1177. From soil.
Carbonate of lime	54.080	48.080
Carbonate of magnesia	39.562	29.666
Alumina, and oxides of iron and manganese	2.980	9.780
Phosphoric acid	.054	trace.
Sulphuric acid	.111	trace.
Potash	.231	.533
Soda	.240	.134
Silex and insoluble silicates	.880	10.580
Water and loss	1.862	1.227
	100.000	100.000

The limestone No. 1177 contains a remarkable quantity of potash, and might prove a hydraulic limestone.

No. 1178—LIMESTONE. *Labeled "Limestone from the Turnpike, head of Mill creek, (used in metaling the road,) Nelson county, Ky." (Sent by S. S. Lyon, Esq.)*

A fine-grained, compact, light-grey limestone, incrusted with and containing irregular veins of calcareous spar, with a bluish-green (or grass-green) mineral under and mixed with the calc. spar. The *green material* is a calcareo-magnesian mineral, colored with oxide of iron; containing no phosphoric acid.

THE COMPOSITION OF THE LIMESTONE IS AS FOLLOWS:

Carbonate of lime	93.980
Carbonate of magnesia	2.797
Alumina, and oxides of iron and manganese	.264
Phosphoric acid	.054
Sulphuric acid	.338
Potash	.189
Soda	trace.
Silex and insoluble silicates	3.040
	100.662

No. 1179—SOIL. *Labeled "Virgin Soil from the land of Wm. Price. Woodland. Forest growth, poplar, beech, hickory. Geological horizon, black slate. Nelson county, Ky."* (Collected by S. S. Lyon, Esq.)

Dried soil of a grey-chocolate color. Some rounded cherty fragments were sifted out of it with the coarse seive.

No. 1180—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Dried soil lighter colored and more yellowish than the preceding. Some cherty and ferruginous fragments were sifted out of it.

No. 1181—SOIL. *Labeled "Soil taken forty yards distant from the preceding two specimens; same geological horizon; from an old field which has not been cultivated for three years. Nelson county Ky."*

Dried soil resembles the last in color. Contains some cherty and ferruginous fragments.

No. 1182—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Dried soil lighter colored and more yellowish than the preceding. Contains some cherty fragments.

No. 1183—SOIL. *Labeled "Soil of an old field; at the horizon of the Upper Silurian rocks. Nelson county, Ky."* (Collected by S. S. Lyon, Esq.)

Dried soil of a dark grey-buff color. Some iron gravel sifted out of it.

No. 1184—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Sifted out a few fragments of iron gravel.

One thousand grains of each of these soils, (air-dried,) digested in water charged with *carbonic acid*, gave up of soluble *materials* as represented in the following table:

	No. 1179. Virgin soil.	No. 1180. Sub-soil.	No. 1181. Old field.	No. 1182. Sub-soil.	No. 1183. Old field.	No. 1184. Sub-soil.
Organic and volatile matters	0.950	0.400	0.350	0.267	0.551	0.407
Alumina, and oxides of iron and manganese and phosphates	.214	.087	.154	.094	.297	.081
Carbonate of lime	1.896	.447	.550	.377	.713	.663
Magnesia	.254	.133	.099	.105	.360	.187
Sulphuric acid	.033	.033	.042	.022	.029	.050
Potash	.083	.050	.040	.018	.048	.045
Soda	trace	.086	.042	.017	.038	.073
Silica	.098	.197	.287	.145	.221	.313
Watery extract, dried at 212° F., (grains)	3.528	1.433	1.564	1.045	2.257	1.819

The *composition* of these soils, dried at 400° F., is given in the following table:

	No. 1179. Virgin soil.	No. 1180. Sub-soil.	No. 1181. Old field.	No. 1182. Sub-soil.	No. 1183. Old field.	No. 1184. Sub-soil.
Organic & vol matters	9.656	3.809	4.586	3.785	5.149	4.705
Alumina	2.365	3.990	2.990	4.590	2.390	4.715
Oxide of iron	3.285	3.910	4.235	5.000	4.035	5.035
Carbonate of lime	.396	.172	.196	.146	.221	.246
Magnesia	.643	1.328	1.214	1.273	.503	.536
Brown oxide of manganese	.310	.310	.220	.245	.195	.120
Phosphoric acid	.378	.161	.208	.162	.161	.342
Sulphuric acid	.076	.127	.050	.059	.084	.050
Potash	.135	.175	.169	.206	.181	.227
Soda	.046	.038	.045	.046	.047	.061
Sand and insoluble silicates	82.870	86.520	87.045	84.895	85.420	83.495
Loss	-------	-------	-------	-------	1.614	.438
Total	100.160	100.540	100.958	100.407	100.000	100 000
Moisture, lost at 400° F., (per cent.)	3.375	1.950	1.885	2.250	2.350	2.775

In these soils, which present general traits of resemblance, there may be observed the usual differences noticed between the composition of the soil of the old field and that of the virgin soil. With the exception of the potash, all the essential ingredients are in smaller proportion in the former than in the latter. A smaller amount of soluble matter also is extracted by the carbonated water from the cultivated soil.

No. 1185—SOIL. *Labeled "Virgin Soil, from the farm of John Troutman. Woodland. Forest growth, beech, sugar-tree, and poplar. Waste of the Black Slate and Upper Silurian Limestone; (above the horizon of the growth of cedar:) Nelson county, Ky." (Procured by S. S. Lyon, Esq.)*

Dried soil of a light chocolate color. Some ferruginous and cherty particles and a small rounded quartz pebble were sifted out with the coarse seive.

No. 1186—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Dried soil a little lighter colored and more yellowish than the preceding.

No. 1187—SOIL. *Labeled "Soil from the farm of Ralph Cotton, north side of Beech Fork of Salt river, five feet above the base of the Black slate. Containing chert of sub-carboniferous origin, Nelson county, Ky."* (Procured by S. S. Lyon, Esq.)

Dried soil of a light chocolate color. A considerable quantity of fragments of decomposed chert were sifted out with the coarse seive.

No. 1188—SOIL. *Labeled "Sub-soil of the preceding, &c."*

Dried soil somewhat lighter colored and more yellowish than the preceding. Some small ferruginous and cherty particles sifted out.

One thousand grains of each of these soils, digested for a month in water charged with carbonic acid, gave up of *soluble matters* as represented in the following table:

	No. 1185. Virgin soil.	No. 1186. Sub-soil.	No. 1187. Soil.	No. 1188. Sub-soil.
Organic and volatile matters	0.783	0.370	[illegible]	0.793
Alumina, and oxides of iron and manganese and phosphates	.131	.131	.147	.054
Carbonate of lime	.530	.147	1.430	.897
Magnesia	.220	.127	[illegible]	.211
Sulphuric acid	[illegible]	.028	not estim'd	.041
Potash	.065	.016	.096	.064
Soda	.064	.096	.116	.123
Silica	.231	.107	.279	.200
Loss	.071	----------	----------	.084
Watery extract, dried at 212° F., (grains)	2.117	1.029	2.890	2.467

The *composition* of these four soils, dried at 400° F., is given in the following table:

	No. 1185. Virgin soil.	No. 1186. Sub-soil.	No. 1187. Soil.	No. 1188. Sub-soil.
Organic and volatile matters	4.521	2.231	5.326	4.355
Alumina	3.749	4.135	2.490	8.140
Oxide of iron	2.860	3.410	4.570	6.885
Carbonate of lime	.196	.071	.371	.422
Magnesia	.337	.423	.545	.736
Brown oxide of manganese	.195	.160	.170	.170
Phosphoric acid	.031	.096	.247	.216
Sulphuric acid	.067	.041	.067	.050
Potash	.164	.164	.246	.743
Soda	.031	.082	.059	.066
Sand and insoluble silicates	87.570	87.845	85.195	78.170
Loss	.279	1.342	.714	.047
Total	100.000	100.000	100.000	100.000
Moisture, lost at 400° F., (per cent.)	3.225	2.425	3.775	5.275

No. 1189—MARLY CLAY. *Labeled "White Clay, (or Sub-soil,) near the road on the farm of Mr. Stephen Cambran. South of the 126th mile of Base Line, Nelson county, Ky."* (*Procured by S. S. Lyon, Esq.*)

A greyish-white clay, mottled with yellowish.

No. 1190—CLAY. *Labeled "Yellowish Clay, (or Sub-soil,) found immediately under the preceding, &c., &c."*

A brownish-yellow, ferruginous clay, or sub-soil.

COMPOSITION OF THESE CLAYS, DRIED AT 212° F.

	No. 1189. Marly clay.	No. 1190. Ferrugin's clay.
Alumina	12.960	15.348
Silica	52.680	54.280
Oxide of iron	6.740	12.940
Carbonate of lime	12.380	1.980
Magnesia	.389	1.216
Brown oxide of manganese	.384	.284
Phosphoric acid	.255	1.088
Sulphuric acid	not estim'd	not estim'd
Potash	2.843	1.371
Soda	not estim'd	.122
Water, expelled at red heat	12.500	11.300
Loss	----------	.071
	101.131	100.000

These clays might probably be used with advantage on soil, in their immediate neighborhood, which has been exhausted by long culture, or which is deficient in lime, alumina, phosphoric acid, or potash.

No. 1191—SOIL. *Labeled "Virgin Soil; from the farm of Hezekiah Mobley. Lick creek; east of Boston, Nelson county, Ky. Ten feet under the level of the Black Slate, and probably derived in part from the Upper Silurian rocks."* (*Obtained by S. S. Lyon, Esq.*)

Dried soil of an umber color. Some fragments of limestone sifted out of it.

No. 1192—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried soil lighter colored and more yellowish than the preceding.

No. 1193—SOIL. *Labeled "Soil from an old field, farm of Hezekiah Mobley. Lick creek; east of Boston, Nelson county, Ky. From the bed of yellowish soil immediately under the Black Devonian Slate. The soil is probably the waste of the upper part of the Yellow (Upper) Silurian rock, and of the slate and shaly beds at the base of the Knob-stone."* (*S. S. Lyon.*)

Dried soil of a light chocolate color, with a tinge of yellowish. Some large cherty and ferruginous particles were sifted out of it.

No. 1194—SOIL. *Labeled "Sub-soil of the preceding, &c., &c."*

Dried sub-soil lighter colored and more yellowish than the preceding.

Some cherty and ferruginous fragments were sifted out of it with the coarse seive.

The quantity of *soluble matters* extracted from a thousand grains of each of these soils, by digestion for a month in water charged with carbonic acid gas, is stated in the following table:

	No. 1191. Virgin soil.	No. 1192. Sub-soil.	No. 1193. Old field.	No. 1194. Sub-soil.
Organic and volatile matters	1.170	0.500	0.673	0.350
Alumina, and oxides of iron and manganese and phosphates	.164	.047	.087	.031
Carbonate of lime	3.913	1.807	.663	.396
Magnesia	.783	.033	.150	.163
Sulphuric acid	.050	.028	.045	.028
Potash	.043	.009	.036	.026
Soda	.043	.043	.022	trace.
Silica	.081	.110	.150	150
Loss	.253			
Watery extract, dried at 212° F., (grains)	6.590	2.577	1.826	1.144

The virgin soil is said by Mr. Lyon to be more immediately derived from the Silurian rocks than the soil of the old field.

The composition of these soils, dried at 400° F., may be seen in the following table:

	No. 1191. Virgin soil.	No. 1192. Sub-soil.	No. 1193. Old field	No. 1194. Sub-soil.
Organic and volatile matters	10.425	6.207	3.286	2.564
Alumina	3.490	10.590	1.190	5.890
Oxide of iron	11.385	13.585	3.670	5.135
Carbonate of lime	6.146	.770	.172	.220
Magnesia	5.710	1.010	.415	.586
Brown oxide of manganese	.145	.645	.228	.170
Phosphoric acid	.275	.367	.047	.079
Sulphuric acid	.058	.050	.050	.058
Potash	.420	.700	.164	.357
Soda	.099	.083	.034	.042
Sand and insoluble silicates	61.495	64.820	89.045	84.820
Loss	.352	1.173	1.699	.079
Total	100.000	100.000	100.000	100.000
Moisture, lost at 400° F., (per cent.)	7.825	9.375	2.625	3.475

The virgin soil is evidently of a different character from the soil of the old field, and probably was more immediately derived from a limestone stratum. It contains a much greater quantity of alumina and oxide of

iron, carbonate of lime, potash, &c., &c., than may be supposed to have originally existed in the old soil. Its proportion of sand, &c., is quite small. If properly drained, it ought to be a very fertile and durable soil.

NELSON COUNTY.

No. 1195—WATER, *sent (October, 21st, 1857) by Dr. J. F. McMillan, of Carlisle, from the only pond in an inclosure, where cattle die of milk-sickness during the dry months, on the farm of B. W. Mathers, near that place. Nicholas county, Ky.*"

The water deposited a sediment in the jug on standing which contained silex, (or fine sand,) alumina, oxide of iron, &c., and appeared to be simply fine earth washed from the soil.

The water was carefully examined and submitted to a thorough analysis and testing for the presence of injurious mineral matters, but nothing of the kind which might be supposed to cause disease was found in it.

The quantity of saline matters which it contained was found to be quite small, only 0.049 per cent., which had the following

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	0.02661	Held in solution by carbonic acid.
Carbonate of magnesia	.00514	
Sulphate of lime	.00048	
Sulphate of magnesia	.00744	
Sulphate of potash	.00225	
Sulphate of soda	.00387	
Chloride of magnesium	.00037	
Silica	.00184	
Loss	.00100	
	0.04900	

This is in the proportion of rather less than three and a half grains of saline matters to the pound avoirdupois of the water.

No. 1196—SOIL. *Labeled "Virgin Soil, from James M. Turner's land, from woodland pasture. Primitive forest growth, white and red oak, poplar, some black ash, wild cherry, and a good deal of beech. Waters of Stoney creek, Nicholas county, Ky. Lower Silurian formation.*"

Dried soil of a yellowish dark grey color.

No. 1197—SOIL. *Labeled "Same Soil as the preceding, from a field which has been more than fifty years in cultivation; lying waste ever since* 1852. *Jas. M. Turner's land, &c., &c.*"

Dried soil, lighter colored and more yellowish than the preceding.

No. 1198—SOIL. *Labeled "Sub-soil of the old field (above described.) Jas. M. Turner's land, &c., &c."*

Dried soil of a greyish-buff color.

One thousand grains of each of these three specimens of soils were digested for a month in water charged with carbonic acid; to which they gave up soluble matters in the proportions stated in the following table:

	No. 1196. Virgin soil.	No. 1197. Old field.	No. 1198. Sub-soil.
Organic and volatile matters	0.927	0.550	0.283
Alumina, and oxides of iron and manganese and phosphates	.174	.121	.030
Carbonate of lime	1.830	0.920	.563
Magnesia	.144	.084	.084
Sulphuric acid	.028	.030	.033
Potash	.093	.022	.019
Soda	.002	.025	.021
Silica	.200	.181	.247
Loss	.145	----------	----------
Watery extract, dried at 212° F., (grains)	3.543	1.933	1.280

The composition of these soils, dried at 400° F., was found to be as follows:

	No. 1196. Virgin soil.	No. 1197. Old field.	No. 1198. Sub-soil.
Organic and volatile matters	7.820	6.339	6.687
Alumina	4.360	6.260	11.235
Oxide of iron	4.465	5.970	7.987
Carbonate of lime	.520	.345	.370
Magnesia	.706	.643	.851
Brown oxide of manganese	.320	.270	.095
Phosphoric acid	.211	.195	.231
Sulphuric acid	.058	.050	.016
Potash	.365	.336	.485
Soda	.131	.071	.078
Sand and insoluble silicates	81.120	79.720	71.870
Loss	----------	----------	.095
Total	100.076	100.199	100.000
Moisture, lost at 400° F., (per cent.)	2.500	2.600	4.150

The soil of the old field does not appear to be as much impoverished as might have been expected; indeed it may be considered still quite fertile; most probably because some of the sub-soil, which is quite rich in the nutritive mineral elements, has become mixed with it in the process of cultivation of the field.

OHIO COUNTY.

No. 1199—Coal. *Labeled "Bull Run Coal, Ohio county, Ky."*

A pure, shining pitch-black coal, which breaks pretty easily, and cleaves into thin layers, with some fibrous coal, like vegetable charcoal, in patches, on the surfaces of the layers; the rest of the surfaces being shining and irregular. Over the spirit lamp it softens and swells up a great deal into a light and spongy coke, giving off much flame. Specific gravity 1.298.

PROXIMATE ANALYSIS.

Moisture	2.60	Total volatile matters	43.80
Volatile combustible matters	41.20		
Fixed carbon (in the coke)	52.66	Light coke	66.20
Purplish-grey ashes	3.54		
	100.00		100.00

The percentage of sulphur was found to be 1.829.

No. 1200—Coal. *Labeled "Crawford's Coal, Ohio county, Ky."*

A rather dull pitch-black coal; rather tough, with an even satiny cross-fracture. No fibrous coal between the layers. Over the spirit lamp it swells a little, gives much smoky flame, and leaves a dense coke. Specific gravity, 1.389.

PROXIMATE ANALYSIS.

Moisture	1.50	Total volatile matters	41.20
Volatile combustible matters	39.70		
Fixed carbon (in the coke)	37.80	Dense coke	58.80
Grey ashes	21.00		
	100.000		100.00

The percentage of sulphur is 3.234.

COMPOSITION OF THE ASH.

Silica	12.084
Alumina, and oxides of iron and manganese	8.280
Lime	.212
Magnesia	.346
Phosphoric acid	a trace.
Sulphuric acid	.132
Potash	.379
Soda	.103
	21.536

The first coal appears to be a good, soft bituminous coal, but the latter contains too much earthy matter and sulphur. The ashes contain more alkaline matter than is generally supposed to be present in coal ash.

OLDHAM COUNTY.

No. 1201—LIMESTONE. *Labeled "Rock from which the white ashy soil was derived.* (See No. 737, in Vol. III, of these Reports;) *one mile northeast of LaGrange, Oldham county, Ky. Upper Silurian formation."*

No. 1202—LIMESTONE. *Labeled "Hydraulic? Limestone, Curry's Fork of Floyd's creek, Oldham county, Ky."*

A fine-granular, dull, greenish-grey rock. Adheres slightly to the tongue.

COMPOSITION OF THESE LIMESTONES, DRIED AT 212° F.

	No. 1201. LaGrange.	No. 1202. Floyd's creek.
Carbonate of lime	41.580	41.980
Carbonate of magnesia	24.030	21.400
Alumina, and oxides of iron and manganese	5.860	6.860
Phosphoric acid	.374	.310
Sulphuric acid	.303	.386
Potash	.455	.370
Soda	.204	.379
Silex and insoluble silicates	23.580	24.680
Water and loss	3.614	3.635
	100.000	100.000

☞ Both of these rocks, which present a striking similarity of composition, would very probably furnish good hydraulic cement, when properly calcined and prepared.

OWEN COUNTY.

No. 1203—MARL. *Labeled "Shale, collected from the spring (now dry) supposed to cause milk-sickness. Waters of Dickey's creek; a mile and a half from Benj. Hayden's, Owen county, Ky."*

A dirty-buff and brownish ferruginous clay-like substance.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	29.247
Alumina, and oxides of iron and manganese	19.940
Carbonate of lime	34.580
Carbonate of magnesia	5.287
Phosphoric acid	.934
Sulphuric acid	.372
Potash	.649
Soda	.000
Water and loss	8.998
	100.000

No. 1204—Soil. *Labeled "Virgin Soil, from woods, on the first farm after ascending the hill from Harmony to Stamping-Ground. Forest growth, white oak on the top of the ridge, some beech on the sides of the hill. Southern edge of Owen county, Ky. Lower Silurian formation."*

Dried soil of a chocolate-grey color.

No. 1205—Soil. *Labeled "Same soil, from an old field; on the road from Harmony to Stamping-Ground, &c., &c."*

Dried soil resembles the preceding.

No. 1206—Soil. *Labeled "Sub-soil of the old field, &c., &c."*

No. 1207—Soil. *Labeled "Virgin Soil; Weston Jenkins' land, two and a half miles from New Liberty, Owen county, Ky. Forest growth, beech. Lower Silurian formation."*

Dried soil of a chocolate-grey color.

No. 1208—Soil. *Labeled "Same soil from a cultivated field on Weston Jenkins' farm, &c., &c."*

Dried soil a little darker colored and slightly browner than the preceding.

No. 1209—Soil. *Labeled "Sub-soil from the same cultivated field, &c., &c.*

Dried soil resembles the preceding.

One thousand grains of each of these soils, digested for a month in water charged with carbonic acid gas, gave up of soluble materials as stated in the following table:

	No. 1204. Virgin soil.	No. 1205. Old field.	No. 1206. Sub-soil.	No. 1207 Virgin soil.	No. 1208. Old field.	No. 1209. Sub-soil.
Organic & vol. matters	0.630	0.517	0.333	0.555	0.450	0.333
Alumina, and oxides of iron & manganese & phosphates	.147	.130	.063	.147	.097	.097
Carbonate of lime	.300	1.330	.42[illegible]	.347	.763	.714
Magnesia	.103	[illegible]	.07	.061	.083	.085
Sulphuric acid	.033	.02[illegible]	.0[illegible]6	.033	.033	.023
Potash	.079	.064	.029	.052	.057	.038
Soda	.031	.02[illegible]	.029	.005	.019	-------
Silica	.414	.131	.213	.164	.254	.231
Loss	.0[illegible]3	.1[illegible]	.049	.086	.097	.104
Watery extract, dried at 212° F., (grains)	1.770	2.470	1.217	1.450	1.853	1.630

The *composition* of these six soils is stated in the following table, viz:

	No. 1204. Virgin soil.	No. 1205. Old field.	No. 1206. Sub-soil.	No. 1207. Virgin soil.	No. 1208. Old field.	No. 1209. Sub-soil.
Organic & vol. matters	4.865	6.026	4.319	4.112	5.218	3.890
Alumina	2.695	3.470	5.280	2.545	3.160	3.695
Oxide of iron	2.810	3.935	5.260	2.995	3.360	3.735
Carbonate of lime	traces.	traces.	traces.	.005	.120	.095
Magnesia	.514	.915	1.178	.666	.708	.746
Brown oxide of manganese	.095	.170	.220	.171	.445	.695
Phosphoric acid	.086	.178	.128	.144	.210	.227
Sulphuric acid	.050	.051	.033	.045	.062	.058
Potash	.094	.089	.271	.116	.149	.133
Soda	.035	.040	.098	.022	.049	.042
Sand and insoluble silicates	88.020	84.870	82.820	88.120	85.970	87.295
Loss	.736	.257	.393	1.039	.549	----------
Total	100.000	100.000	100.000	100.000	100.000	100.611
Moisture, lost at 400° F (per cent.)	2.375	2.925	2.775	2.515	2.750	2.525

These soils, which are much poorer than those based on the *blue limestone* of the Lower Silurian formation, would be benefited by top-dressings of lime or marl. Such a marl as No. 1203, from this county, described above, would answer the purpose admirably.

OWSLEY COUNTY.

No. 1210—CARBONATE OF IRON. *Labeled "Carbonate of Iron incrusted with gypsum, disseminated in the black shales twenty-three feet above coal No. 2, Proctor, Owsley, county, Ky."* (Obtained by Messrs. Downie and Lesquereux.)

A dark-grey, fine-grained carbonate, in flat pieces about an inch thick; surfaces on both sides changed into dark brown peroxide. Powder of a dark dirty buff color. Specific gravity 3.271.

No. 1211—CARBONATE OF IRON. *Labeled "Iron Ore from the north bank of the North Fork of the Kentucky river, forty feet above the river surface; on the land of John G. McGuire, one mile above Proctor, Owsley county, Ky."* (Obtained by Jos. Lesley, jr.) Geological position, *between the main and upper beds of coal.*

Portion of a large nodule of compact, fine-grained, dark-grey carbonate of iron. Exterior surface, and surfaces of the cracks, with a thin coating of yellowish peroxide. Some of the fissures filled with calc. spar. Specific gravity 3.405.

COMPOSITION OF THESE TWO ORES, DRIED AT 212° F.

	No. 1210. Proctor ore.	No. 1211. Ore, 1 mile above Proctor.
Carbonate of iron	38.321	62.292
Oxide of iron	22.564	7.726
Alumina	.680	.520
Carbonate of lime	.158	1.984
Carbonate of magnesia	8.414	8.885
Carbonate of manganese	1.023	1.324
Phosphoric acid	.759	1.463
Sulphuric acid	.372	.510
Potash	.309	.282
Soda	.290	.347
Silex and insoluble silicates	22.580	11.980
Bituminous matter and loss	4.620	2.687
Total	100.000	100.000
Percentage of metallic iron	34.304	35.400
Moisture, lost at 212° F., (per cent.)	0.70	0.60

Rich enough to be profitably smelted into iron, but containing rather more phosphoric acid than is desirable in iron ore.

No. 1212—SALINE EFFLORESCENCE *called in the neighborhood "nitre;" on the shale with the carbonate of iron. Proctor, Owsley county, Ky.* (Collected by Messrs. Downie and Lesquereux.)

White satiny, acicular, crystalline powder, on and mixed with fragments of shale. The solution in water was neutral. It is pretty pure *sulphate of magnesia, or Epsom salt.*

No. 1213—COAL. *Labeled "Coal from the Big Vein, about three feet to three feet ten inches thick, owned by Philips; on the west side of Mirey branch; about a thousand feet from the river, and one mile from Proctor, Owsley county, Ky. Geological position, under the conglomerate or millstone grit."* (Obtained by Jos. Lesley, jr.)

A pure looking, deep pitch-black coal, with some fibrous coal between the layers. Over the spirit lamp it softened, agglutinated, and swelled into a rather dense coke; with much smoky flame. Specific gravity 1.275.

PROXIMATE ANALYSIS.

Moisture	2.06	Total volatile matters	36.40
Volatile combustible matters	34.[illegible]4		
Fixed carbon in the coke	56.50	Moderately dense coke	63.60
Light grey ashes	7.10		
	100.00		100.00

The percentage of *sulphur* was found to be 0.796.

Silica	3.984
Alumina, and oxides of iron and manganese	2.380
Lime	.103
Magnesia	.286
Sulphuric acid	not estimated.
Potash	.231
Soda	.175
	7.159

No. 1214—COAL. *Labeled "Coal from McGuire's 'Big Vein,' on Upper Stufflebean creek; half a mile north of Proctor, Owsley county, Ky. Geological position, under the conglomerate."* (Obtained by Joseph Lesley, jr.)

A pure, deep-pitch-black, shining coal. Some fibrous coal between the layers. Over the spirit lamp it softened and agglutinated and swelled into a moderately dense coke. Specific gravity 1.235.

PROXIMATE ANALYSIS.

Moisture	2.30	Total volatile matters	39.60
Volatile combustible matters	37.30		
Fixed carbon (in the coke)	58.90	Moderately dense coke	60.40
Light-tawny ashes	1.50		
	100.00		100.00

The percentage of sulphur was found to be 0.645.

COMPOSITION OF THE ASH.

Silica	0.324
Alumina, and oxides of iron and manganese	.680
Lime	a trace.
Magnesia	.260
Sulphuric acid	.132
Alkalies and loss	.104
	1.500

No. 1031*—COAL. *Labeled "Coal from Beatty's river bank big vein; ninety feet above the river, at its north side, between Lower Stufflebean creek and Miry branch, and nearly opposite to Proctor, Owsley county, Ky."* Geological position, *under the conglomerate or millstone grit."* (Obtained by Jos. Lesley, jr.)

A pure deep-pitch-black, shining coal; with fibrous coal between the layers. Over the spirit lamp it softens and agglutinates, gives much smoky flame, and leaves a moderately dense coke. Specific gravity, 1.338.

* This and the following number, 1031, accidentally omitted in their proper places, are introduced here.

PROXIMATE ANALYSIS.

Moisture	1.50	Total volatile matters	38.26
Volatile combustible matters	36.76		
Fixed carbon (in the coke)	55.14	Moderately dense coke	61.74
Grey-purple ash	6.60		
	100.00		100.00

The percentage of sulphur is 4.074.

COMPOSITION OF THE ASH.

Silica	1.284
Alumina, and oxides of iron and manganese	4.380
Lime	a trace.
Magnesia	.266
Sulphuric acid, alkalies, and loss	.670
	6.600

POWELL COUNTY.

No. 1032—CARBONATE OF IRON. *Labeled "Knob Iron Ore, above Stanton, Powell county, Ky."*

A fine-grained, dark-grey ore; weathered surfaces dull reddish-brown and yellowish. Powder yellowish grey. Specific gravity 3.3571.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	51.082	=32.021 per cent. of iron.
Oxide of iron	10.500	
Alumina	2.480	
Carbonate of lime	5.780	
Carbonate of magnesia	10.048	
Carbonate of manganese	4.034	
Phosphoric acid	1.088	
Sulphuric acid	.235	
Potash	.527	
Soda	.267	
Silex and insoluble silicates	14.040	
	100.081	

No. 1215—SOIL. *Labeled "Virgin Soil, from Moses S. Conner's farm, near Red river, Powell county, Ky. Principal forest growth, small white oak, also some hickories of small size. This soil is chiefly derived from the Black Devonian shale."*

Dried soil of a dark umber-grey color. A considerable quantity of fragments of dark grey and soft red ferruginous slaty sandstone was sifted out of this soil with the coarse seive.

No. 1216—SOIL. *Labeled "Same Soil, from an old field, fifteen to twenty years in cultivation. Moses S. Conner's farm, &c., &c."*

Dried soil of a buff-grey color. Contains fragments of red ferruginous slaty sandstone, but not so much as the preceding.

o. 1217—SOIL. *Labeled "Sub-soil, from the same old field. Moses S. Conner's farm, &c., &c."*

Dried sub-soil of a light, greyish-buff color. Contains fragments of ferruginous sandstone, like the preceding. These were sifted out with the coarse seive before proceeding to the analysis.

One thousand grains of each of these soils were digested for a month in water charged with carbonic acid gas, to which they gave up soluble materials as represented in the following table:

	No. 1215. Virgin soil.	No. 1216. Soil of old field.	No. 1217. Sub-soil.
Organic and volatile matters	1.617	0.566	0.460
Alumina, and oxides of iron and manganese and phosphates	.714	.314	.181
Carbonate of lime	.280	.517	.147
Magnesia	.098	.118	.223
Sulphuric acid	.033	.019	.045
Potash	.114	.087	.049
Soda	.037	.037	.021
Silica	.200	.200	.200
Loss	.042	.045	------
Watery extract, dried at 212° F., (grains)	3.135	1.903	1.326

The *composition* of these soils, dried at 400° F., was found to be as follows, viz:

	No. 1215. Virgin soil.	No. 1216. Soil of old field.	No. 1217. Sub-soil.
Organic and volatile matters	8.033	5.102	3.625
Alumina	3.215	4.300	4.690
Oxide of iron	4.885	5.285	5.885
Carbonate of lime	.095	.070	.020
Magnesia	.581	.420	.540
Brown oxide of manganese	.130	.220	.145
Phosphoric acid	.278	.174	.143
Sulphuric acid	.278	.110	.067
Potash	.579	.290	.350
Soda	.031	.187	.067
Sand and insoluble silicates	81.795	83.820	83.940
Loss	.100	.022	.528
Total	100.000	100.000	100.000
Moisture, lost at 400° F., (per cent.)	2.90	2.00	1.815

The large proportion of potash in these soils shows their origin from the black slate. They ought to be fertile and durable soils. The only deficiency observed in their composition is in the *lime*, which can easily

be supplied in top-dressing, and which will, no doubt, much increase their productiveness.

PULASKI COUNTY.

No. 1218—CARBONATE OF IRON; *from the coal mines of the Cumberland Coal Company; near the Falls of the Cumberland river, Pulaski county, Ky.*" (Sent by Gov. R. P. Letcher.)

A dark-grey, or mouse-colored, fine-grained, compact, carbonate of iron. Weathered surfaces reddish and yellowish. The specimen is apparently from a layer about three and a half inches thick.

COMPOSITION, DRIED AT 212° F.

Carbonate of iron	79.781	=39.638 per cent. of iron.
Oxide of iron	1.561	
Alumina	1.060	
Carbonate of lime	1.580	
Carbonate of magnesia	3.094	
Carbonate of manganese	.120	
Phosphoric acid	.758	
Sulphuric acid	.269	=0.108 per cent. sulphur.
Potash	.212	
Soda	.034	
Bituminous matter	.820	
Silex and insoluble silicates	8.780	
Loss	1.931	
	100.000	

Quite a rich carbonate of iron.

ROCKCASTLE COUNTY.

No. 1219—COAL, *from Wm. Dyre's bank; on McClure branch of West Fork of Skegg's creek; about eight miles east of south from Mount Vernon, Rockcastle county, Ky. Bed only stripped; three feet disclosed, but is about forty inches thick, with about a three feet head of black slate roofing.*" (Obtained by Joseph Lesley, jr.)

Rather a dull-looking coal; pretty tough; not much fibrous coal between the layers. Exterior stained with ochreous oxide of iron. Over the spirit lamp it swelled up into a spongy coke. Specific gravity 1.249.

PROXIMATE ANALYSIS.

Moisture	1.66	Total volatile matters	39.40
Volatile combustible matters	37.74		
Fixed carbon (in the coke)	58.26	Spongy coke	60.60
Buff-grey ashes	2.34		
	100.00		100.00

The percentage of *sulphur* is 0.818.

No. 1220—COAL. *"From Henry Mullin's bank; in a ridge which divides Roundstone from Skegg's creek waters; one mile southwest of his house, and five miles southeast of Mt. Vernon, Rockcastle county, Ky. Bed forty inches thick, with a capping of three feet of very hard, bluish, slaty shale; and above it six feet of blue shale." (Obtained by Jos. Lesley, jr.)*

Resembles the preceding. Over the spirit lamp it behaved like that. Specific gravity, 1.259.

PROXIMATE ANALYSIS.

Moisture	1.70	Total volatile matters	38.00
Volatile combustible matters	36.30		
Fixed carbon (in the coke)	59.80	Moderately dense spongy coke	62.00
Light-grey ashes	2.20		
	100.00		100.00

The percentage of *sulphur* was found to be 0.685.

COMPOSITION OF THE ASH.

Silica	0.784
Alumina, and oxides of iron and manganese	.580
Carbonate of lime	.084
Magnesia	.366
Sulphuric acid	.111
Potash	.046
Soda	.343
	2.314

ROWAN COUNTY.

No. 1221—SANDSTONE. *Labeled "Knob Building Stone; mouth of Triplett creek, edge of Rowan county, Ky."*

A fine-grained, grey sandstone. Adheres to the tongue. Powder nearly white. Specific gravity, 2.539.

Dried at 212°, its powder lost 0.40 per cent. of *moisture.*

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	90.240
Alumina, and oxides of iron and manganese	3.965
Carbonate of lime	1.480
Magnesia	.932
Phosphoric acid	.117
Sulphuric acid	.269
Potash	.336
Soda	.089
Water, expelled at a red heat	2.900
	100.328

The fact that this sandstone adheres to the moist tongue indicates that it will absorb moisture; and, consequently, be liable to disintegration under the influence of frost.

No. 1222—SOIL. *Labeled "Virgin Soil, near Morehead, Rowan county, Ky. Forest growth, white oak, chestnut, hickory, beech; some sugar-tree and black walnut."*

Dried soil of a dirty, greyish-buff color. Some fragments of soft sandstone were sifted out of it with the coarse seive.

No. 1223—SOIL. *Labeled "Soil from a farm in Morehead, Rowan county, Ky., fifty or sixty years in cultivation. Knob formation."*

Dried soil of a greyish-buff color, lighter colored than the preceding.

One thousand grains of each of these soils, digested for a month in water charged with carbonic acid, gave up of *soluble materials* as follows, viz:

	No. 1222. Virgin soil.	No. 1223. Old field.
Organic and volatile matters	1.266	0.507
Alumina, and oxides of iron and manganese and phosphates	.214	.124
Carbonate of lime	.347	.730
Magnesia	.127	.366
Sulphuric acid	.028	.022
Potash	.069	.045
Soda	.029	.020
Silica	.081	.114
Watery extract, dried at 212° F., (grains)	2.161	1.928

The composition of these two soils, dried at 400° F., is as follows:

	No. 1222. Virgin soil.	No. 1223. Old field.
Organic and volatile matters	5.461	3.797
Alumina	3.490	3.165
Oxide of iron	3.085	1.885
Carbonate of lime	.220	.195
Magnesia	.311	.279
Brown oxide of manganese	.195	.060
Phosphoric acid	.078	.095
Sulphuric acid	.110	.028
Potash	.400	.191
Soda	.022	.025
Sand and insoluble silicates	86.520	90.420
Loss	.108	---------
Total	100.000	100.140
Moisture, lost at 400° F.	1.850	1.250

The only deficiency observed in the composition of the virgin soil of this locality, is in the proportion of *phosphoric acid.* The addition of ground bones, or of super-phosphate of lime, or guano, would doubtless make it quite productive. The soil of the old field exhibits the usual signs of partial exhaustion: it may be improved by the same means, just indicated, with the addition of wood ashes.

SCOTT COUNTY.

No. 1224—"SHALE, *from milk-sick district. Floyd's Fork of Big Eagle, Scott county, Ky.*"

A friable, dirty-grey-buff shale. Powder of a light buff color.

No. 1225—"MUDSTONE, *from milk-sick district. Floyd's Fork of Big Eagle, Scott county, Ky.*" (*From near a sheep farm where the disease was more prevalent than ordinary.*)

A friable, dirty-buff, shaly rock. Adheres to the tongue.

COMPOSITION OF THESE ROCKS, DRIED AT 212° F.

	No. 1224. Shale.	No. 1225. Mudstone.
Sand and insoluble silicates	75.920	77.840
Alumina, and oxides of iron and manganese	11.660	9.140
Carbonate of lime	1.480	3.784
Carbonate of magnesia and loss	6.220	3.401
Phosphoric acid	.482	.566
Sulphuric acid	.338	.303
Potash	not estim'd	.579
Soda	not estim'd	.047
Water, expelled at a red heat	3.900	4.340
	100.000	100.000

These shales were fully tested for traces of the poisonous metals, but nothing was found in them which might be supposed to occasion the endemic disease.

TRIGG COUNTY.

No. 1226—LIMONITE. *Labeled "Pot Ore from D. Hillman's Empire Furnace, Trigg county, Ky.*"

A curved, irregular layer of dense, dark colored limonite, inclosing a large cavity, through the walls of which project some remains of coralloid bodies, (probably cyathophylli.) Exterior, soft ochreous ore, of

red, yellow, and brown colors. Powder of a handsome Spanish-brown color.

No. 1227—LIMONITE. *Labeled "Brown Ore, Empire Furnace, &c."*

A dense, dark-brown limonite; in pretty thick irregularly curved layers, incrusted with bright red, yellow, and brown soft ochreous ore. Powder of a brownish-yellow color.

COMPOSITION OF THESE TWO ORES, DRIED AT 212° F.

	No. 1226. Pot ore.	No. 1227. Brown ore.
Oxide of iron	86.540	68.540
Alumina	.580	.480
Carbonate of lime	a trace.	trace.
Magnesia	.289	.854
Brown oxide of manganese	.184	.384
Phosphoric acid	.374	.156
Sulphuric acid	.166	.122
Potash	.193	.502
Soda	.076	.129
Silex and insoluble silicates	7.080	17.100
Combined water	5.560	11.180
Loss	----------	.553
Total	101.042	100.000
Moisture, expelled at 212° F.	1.400	1.600
Percentage of metallic iron	60.605	48.009

The "pot ore" is the richer, but the "brown ore" will doubtless yield the tougher iron of the two.

No. 1228—LIMESTONE. *Labeled "Grey Limestone used as a flux at Empire Furnace, Trigg county, Ky."*

A moderately coarse-grained dark-grey limestone, containing fossils and presenting shining crystalline facets.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	93.040=52.21 per cent. of lime.
Carbonate of magnesia	1.259
Alumina, and oxides of iron and manganese	2.980
Phosphoric acid	none.
Sulphuric acid	.242
Potash	.193
Soda	.179
Silex and insoluble silicates	1.980
Loss	.127
	100.000

Well suited for the use to which it is applied; especially as it contains no *phosphoric acid.* It would be still better did it contain less *sulphuric acid.*

No. 1229—Iron Furnace Slag. *Labeled "Slag from Empire Furnace, Trigg county, Ky."*

A dense, smoky-blue and grey-blue slag; mottled with dark (carbonaceous?) matter; opalescent; translucent on the thin edges; containing a few air-bubbles. Before the blow-pipe it easily fuses into a light bottle-green glass.

COMPOSITION.

Silica	64.480	Containing oxygen=33.485	
Alumina	5.280	2.468	
Lime	19.317	5.493	
Magnesia	1.304	.421	
Protoxide of iron	6.462	1.434	
Protoxide of manganese	.911	.204	
Phosphoric acid	trace.		
Sulphuric acid	trace.		
Potash	1.953	.312	
Soda	.319	.182	
	100.026	10.514	33.485

The oxygen in the bases is to that in the silica, as 10.514 is to 33.485
or as 1 is to 3.204

This slag approaches very nearly, in composition, to what is called a *tri-silicate;* and the large proportion of protoxide of iron in it (6.462 per cent.) shows that the addition of more limestone to the flux would be beneficial. By reference to the former volumes of the Report, it will be seen that most of the charcoal furnaces in the northern portion of the State use limestone enough to produce a *bi-silicate* slag; and doubtless the larger quantity of lime tends to remove sulphur and other impurities injurious to the iron. The addition of some aluminous material, (free from phosphoric acid,) to the flux of the Empire furnace, might also be an improvement.

No. 1230—Pig Iron. *Labeled "Sharp Iron, Empire Furnace, &c."*

A fine-grained, dark-grey iron. Yields to the file and extends somewhat under the hammer.

No. 1231—Pig Iron. *Labeled "Foundry Iron, Empire Furnace, &c., &c."*

Rather a fine-grained, dark-grey iron. Yields easily to the file; in small fragments breaks readily under the hammer.

No. 1232—Pig Iron. *Labeled "White Iron, Empire Furnace, &c., &c."*

Very hard and brittle; quite light colored: presenting a confused, bladed, semi-crystalline appearance on the fractured surfaces. Dissolves with difficulty, in dilute acids, and by means of iodine in warm water.

COMPOSITION OF THESE THREE SPECIMENS OF PIG IRON.

	No 1230. Sharp iron.	No. 1231. Foundry iron.	No. 1232. White iron.
Iron	92.984	93.686	95.747
Graphite	2.700	3.200	trace.
Combined carbon	2.060	1.360	2.400
Manganese	.132	.133	.334
Silicon	1.104	1.536	.373
Slag	.284	.136	.104
Aluminum	.177	.307	.149
Calcium	trace.	trace.	trace.
Magnesium	.226	.264	.224
Potassium	.052	.104	.157
Sodium	trace.	trace.	trace.
Phosphorus	.249	.389	.333
Sulphur	.094	.226	.080
Loss			.099
Total	100.062	101.341	100.000
Total carbon	4.760	4.560	2.400
Specific gravity	7.0629	7.4872	7.6095

For the analysis of the hearth sandstone used at this furnace, see *Union county.*

The specimens from the Trigg county furnaces were collected by Mr. Jno. Bartlett.

No. 1233—Limonite. *Labeled "'Pot Ore,' from the ore beds of Centre Furnace, two and a half miles back of Empire Furnace, Trigg county, Ky."*

A geode formed of a layer of dense, dark-brown limonite, about half an inch in thickness, forming the walls of an irregular cavity, three to four inches in diameter. Exterior of the geode composed of soft ochreous ore. Interior surface generally hard, and sometimes beautifully iridescent, sometimes smooth and polished, mammillary, or botryoidal. Occasionally the cavity of the geode contains clay, casts of fossil shells, or crystals of sulphate of lime; almost always they are filled with water and mud, the analyses of some specimens of which are given below.

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These geodes of limonite, called by the furnace men "pots," are frequently found of very great size. The powdered ore is of a reddish-brown color.

No. 1234—LIMONITE. *Labeled "Brown Ore, Centre Furnace Ore Bed, Trigg county, Ky."*

A dense, dark-brown limonite, in thick irregular layers coated with red, ochreous ore. Powder brownish-yellow.

No. 1235—LIMONITE. *Labeled "Brown Ore from a bed close to Centre Furnace, Trigg county, Ky. Too near to the furnace to be worked; considered superior ore by the manager."*

A dense, dark-brown limonite; containing several small cavities lined with small quartz crystals, and a silicious incrustation. Powder of a yellowish-brown color.

COMPOSITION OF THESE THREE ORES, DRIED AT 212° F.

	No. 1233. Pot ore.	No. 1234. Brown ore.	No. 1235. Brown ore near furnace.
Oxide of iron	78.840	73.540	73.340
Alumina	1.380	1.380	.921
Carbonate of lime	trace.	trace.	trace.
Magnesia	.873	.500	.527
Brown oxide of manganese	.980	.640	.444
Phosphoric acid	.483	.220	.159
Sulphuric acid	.441	.097	.475
Potash	.270	.359	.289
Soda	.197	.123	.043
Silex and insoluble silicates	11.580	9.740	15.380
Combined water	3.720	11.320	9.460
Loss	1.236	2.081	----------
Total	100.000	100.000	101.038
Percentage of metallic iron	47.230	51.511	51.361
Moisture, expelled at 212° F.	0.600	0.340	0.400

No. 1236—LIMESTONE. *Labeled "Limestone, used as flux at Centre Furnace, Trigg county, Ky. Found in the neighborhood."*

A grey, fossiliferous limestone; glistening with small crystalline facets of calcareous spar.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	94.940=53.276 per cent. of lime.
Carbonate of magnesia	1.958
Alumina, and oxides of iron and manganese	.280
Phosphoric acid	.156
Sulphuric acid	not estimated.
Potash	.181
Soda	.166
Silex and insoluble silicates	2.840
	100.521

No. 1237—IRON FURNACE SLAG. *Labeled "Slag from the Grey Iron, Centre Furnace, &c."*

Translucent, purplish-blue, marbled with opalescent grey-blue. Before the blow-pipe fuses readily into a clear glass, which becomes filled with air-bubbles on continuing the heat in the oxidating flame.

No. 1238—IRON FURNACE SLAG. *Labeled "Slag from the Lively-Grey Iron, Centre Furnace, &c."*

Olive-green, translucent on the edges; containing many large air-bubbles, as well as numerous minute ones. Before the blow-pipe it is not so fusible as the preceding: melting into an olive-green glass.

COMPOSITION OF THESE SLAGS.

	No. 1237.		No. 1238.	
	Slag (grey iron.)	Oxygen.	Slag (Lively-grey.)	Oxygen.
Silica	65.140	= 33.822	63.680	= 33.064
Alumina	7.580	= 3.543	8.880	= 4.150
Lime	22.715	= 6.761	21.088	= 6.002
Magnesia	.826	= .330	.965	= .385
Protoxide of iron	1.404	= .310	2.502	= .555
Protoxide of manganese	.171	= .038	.632	= .142
Phosphoric acid	marked traces.		marked traces.	
Sulphuric acid	not estimated.		.269	
Potash	1.564	= .265	1.630	= .276
Soda	.228	= .038	.180	= .056
Loss	.372		.174	
Total	100.000	11.305	100.000	11.566
The oxygen in the bases is to that in the silica as	11.305 to 33.822		11.566 to 33.064	
or as	1 to 2.991		1 to 2.859	

These approach very nearly to the composition of *tri-silicates.*

No. 1239—PIG IRON. *Labeled "Grey, or Foundry Iron, Centre Furnace, &c."*

A dark-grey iron, moderately coarse grained, specular; the flat gran-

ules being quite brilliant. Yields easily to the file. Small fragments easily crushed under the hammer.

No. 1240—Pig Iron. *Labeled "Lively Grey Iron, (forging,) Centre Furnace, &c.*

A fine-grained, light-grey iron; quite hard; yields with difficulty to the file. Extends very little under the hammer; small fragments soon break to pieces when hammered.

COMPOSITION OF THESE TWO SPECIMENS OF PIG IRON.

	No. 1239. Grey iron.	No. 1240. Lively grey iron.
Iron	94.786	96.212
Graphite	2.500	2.000
Combined carbon	1.700	1.000
Manganese	.133	.133
Silicon	1.345	.624
Slag	.184	.184
Aluminum	.177	.177
Calcium	trace.	trace.
Magnesium	.285	.333
Potassium	.048	.070
Sodium	.042	.065
Phosphorus	.080	.108
Sulphur	.122	.152
Total	101.402	101.058
Total carbon	4.200	3.000
*Specific gravity	7.1256	7.4108

By the kindness of Mr. S. S. Goodrich, of Centre furnace, I was supplied with two specimens of the water contained in the cavities of the 'pot ore' of this region, and was thus enabled to submit it to analysis, as follows:

No. 1241—Water from interior of Pot Ore, *Centre Furnace, Trigg, county, Ky., labeled "Liquid from interior of Pot Ore.* The walls of the 'pot' were solid and compact, and from one to three inches thick. This 'pot' was surrounded by, or a part of, a lump of ore that would have weighed six tons (!) and it was taken from near the middle."

The liquid, which was sent to me in a bottle, (marked No. 1,) contained a large proportion of tenaceous dark-brown mud. (See below for

analysis of this sediment.) The cork of the bottle was sensibly darkened, as by the action of a salt of iron.

Evaporated to dryness at 212°, the filtered liquid left only 0.405 per cent. of *saline matters;* which was principally composed of *sulphates of magnesia, lime,* and *manganese,* with a little *sulphate of iron,* and a small proportion of *chlorides.*

No. 1242—WATER FROM THE INTERIOR OF POT ORE, *Centre Furnace, &c.,* labeled "Liquid from a large 'pot' embedded in clay. It was rolled out and broken, and found to contain nearly three quarts of the liquid. The shell was from one to four inches thick." (Sent by S. S. Goodrich, Esq.) *Bottle No.* 2.

There was a small quantity of brownish sediment in the bottle. The cork was only slightly deepened in color. Specific gravity 1.0065.

Evaporated to dryness, it left 0.84 per cent. of *saline matters,* dried at 212° F., which was of the following

COMPOSITION:

Sulphate of manganese	0.308	
Sulphate of magnesia	.265	
Sulphate of potash	.009	
Sulphate of lime	.136	
Chloride of sodium	.037	
Carbonates of lime, magnesia and iron and loss	.085	
Saline matters, dried at 212°	0.840	per cent.

No. 1243—"*Sediment from the water inclosed in the Pot Ore, Centre Furnace, Trigg county, Ky.*"

An umber colored earthy material, in soft friable lumps.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	88.380
Alumina, and oxides of iron and manganese	3.580
Lime	a trace.
Magnesia	.700
Phosphoric acid	.092
Sulphuric acid	not estimated.
Potash	.722
Soda	.296
Carbonaceous matter	3.000
Water, expelled at red heat	3.240
	100.010

The presence of the above described saline solution in the interior of the "pot ore," where it has probably existed for ages, is a singular fact; which may throw some light on the character of the chalybeate

water from which the hydrated oxide of iron (limonite) was originally deposited. The sediment examined is an earthy matter, or dried mud, of the nature of common soil.

No. 1244—LIMONITE. *Labeled "Pot Ore, from Fulton Furnace; two and a half miles northwest of Empire Furnace, Trigg county, Ky."*

A dense, dark brown layer, incrusted with cinnamon colored ochreous limonite, and including an irregular cavity. Powder yellowish-brown.

No. 1245—LIMONITE. *Labeled "Brown Ore, from Fulton Furnace, &c., &c."*

A dense, dark brown limonite; not adhering to the tongue; covered with brownish-yellow ochreous ore. Powder yellowish-brown.

COMPOSITION OF THESE TWO LIMONITES, DRIED AT 212° F.

	No. 1244. Pot ore.	No. 1245. Brown ore.
Oxide of iron	77.070	73.680
Alumina	.480	.380
Lime	a trace.	trace.
Magnesia	.773	.649
Brown oxide of manganese	.580	.360
Phosphoric acid	.438	.856
Sulphuric acid	.097	.097
Potash	.308	.231
Soda	.270	.021
Silex and insoluble silicates	9.480	13.280
Combined water	11.100	10.800
Total	100.596	100.354
Percentage of metallic iron	53.973	51.599
Moisture, expelled at 212° F.,	0.800	0.900

The "brown ore" contains more phosphoric acid than the "pot ore," and hence the iron made from it may not be so tough as that from the latter.

No. 1246—LIMESTONE. *Labeled "Grey Limestone used as a flux at Fulton Furnace. Found near the Furnace."*

A grey, fossiliferous, fine-grained limestone; glimmering with small facets of calc. spar.

No. 1247—LIMESTONE. *Labeled "Black Limestone, sometimes used as a flux at Fulton Furnace; but the grey is considered the best, and is now used."*

A dark-umber colored limestone, (nearly black.) Bituminous and fossiliferous. Fine granular with small facets of calc. spar.

Powder of a buff-grey color.

COMPOSITION OF THESE TWO LIMESTONES, DRIED AT 212° F.

	No. 1246. Grey limestone.	No. 1247. Black limestone
Carbonate of lime	88.180	69.080
Carbonate of magnesia	4.335	2.168
Alumina, and oxides of iron and manganese	.280	2.440
Phosphoric acid	trace.	.335
Sulphuric acid	.180	.532
Potash	.251	.355
Soda	.054	.232
Silex and insoluble silicates	9.520	21.840
Loss and bituminous matters		2.978
Total	102.800	100.000
Moisture, expelled at a red heat	0.200	0.200
Percentage of pure lime	.487	38.764

The *grey* is obviously a better limestone for the flux for the iron furnace than the black, containing more *lime* and being more free from injurious impurities. The black limestone is the best for agricultural purposes, for spreading on land to increase its productiveness; for which it is very well adapted by its large proportions of phosphoric and sulphuric acids and the alkalies.

No. 1248—IRON FURNACE SLAG. *Labeled "Slag from the Fulton Furnace, Trigg county, Ky."*

A dense, greyish light blue, translucent, and bluish-grey opake and opalescent slag. Before the blow-pipe, it fuses without difficulty into a clear light bottle-green glass.

COMPOSITION.

Silica	64.880	Containing oxygen	=33.687
Alumina	8.980	4.197	
Lime	21.200	6.028	
Magnesia	1.087	.434	
Protoxide of manganese	.540	.121	
Protoxide of iron	2.660	.590	
Potash	1.533	.260	
Soda	.358	.092	
	101.238 oxygen as	11.722	to 33.687
Oxygen in the bases is to that in the silica, as		1	is to 2.874

This slag was found to contain phosphoric acid also, but its quantity was not estimated. This slag approaches in composition to what is called a *tri-silicate.* More limestone in the flux could be advantageously employed at this furnace.

No. 1249—PIG IRON. *Labeled "Sharp Iron, (lively grey,) for forging, Fulton Furnace, Trigg county, Ky."*

A fine grained, dark-grey iron. Yields easily to the file. Small fragments extend a little under the hammer, but soon break to pieces.

No. 1250—PIG IRON. *Labeled "Grey Iron, used for foundry purposes, Fulton Furnace, &c, &c."*

A moderately coarse-grained iron, with brilliant flattened grains, (specular?) Yields easily to the file. In small fragments it crushes easily under the hammer, and does not extend much.

	No. 1249. Sharp iron.	No. 1250. Grey iron.
Iron	93.546	93.204
Graphite	3.360	2.500
Combined carbon	1.640	1.800
Manganese	.276	.276
Silicon	1.008	1.008
Slag	.184	.884
Aluminum	.069	.095
Calcium	trace.	trace.
Magnesium	.264	.311
Potassium	.064	.064
Sodium	.070	.070
Phosphorus	.192	.252
Sulphur	trace.	.053
Total	100.673	100.517
Total carbon	5.000	4.300
Specific gravity	7.1440	6.918

The "sharp iron" is quite a pure specimen, and ought to produce tough malleable iron.

TRIMBLE COUNTY.

No. 1251—FOSSIL SHELLS. *Labeled "Murchisonia sp? Trimble county, Ky. What composition?"*

Detached specimens of fossil shells of the genus Murchisonia, with their cavities filled with calc. spar and limestone.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	94.880
Carbonate of magnesia	1.119
Alumina, and oxides of iron and manganese	.680
Phosphoric acid	.059
Sulphuric acid	.200
Potash	.193
Soda	.082
Silex and insoluble silicates	2.480
Loss	.307
	100.000

They do not differ much in composition from the limestone in which they are found.

UNION COUNTY.

No. 1252—IMPURE BITUMINOUS LIMONITE. *Labeled "Black Band Iron Ore. Over the first coal at Curlew Mines, Union county, Ky."*

A dull, almost black, shaly ore; very full of small particles of yellow iron pyrites, and covered with effloresced sulphate of iron. Powder nearly black.

COMPOSITION, DRIED AT 212° F.

Oxide of iron	38.240	
Alumina	.778	
Carbonate of lime	.580	
Magnesia	.615	
Brown oxide of manganese	.580	
Phosphoric acid	.502	
Sulphuric acid	1.426	=1.775 sulphur.
Potash	.328	
Soda	.201	
Silex and insolubie silicates	11.300	
Bituminous matters	37.800	
Combined water	5.100	
	100.450	

Dried at 212° F., it lost as much as 7.60 per cent. of moisture. Too impure to be used as an ore of iron.

No. 1253—SANDSTONE. *Labeled "Hearth-stone used at Empire Furnace, (Trigg county,) brought from Caseyville, Union county, Ky."*

A friable sandstone, made up of clear rounded grains of quartz; some parts without any appearance of cement; in other parts brown from the presence of oxide of iron, &c. Powder of a light buff color.

COMPOSITION, DRIED AT 212° F.

Sand and insoluble silicates	94.080
Alumina, and oxides of iron and manganese	2.660
Lime	trace.
Magnesia	.733
Phosphoric acid	.092
Sulphuric acid	.097
Potash	.250
Soda	.103
Water, expelled at red heat	1.700
Loss	.285
	100.000

Dried at 212° F., it lost 0.30 per cent. of *moisture.*

A similar sandstone from this county, used for hearth-stone at Suwannee furnace, is described under the head of Lyon county.

No. 1254—COAL, (*cannel.*) *Labeled "Upper part of Payne and Berry's Coal, Union county, Ky."*

General color dull black, with irregular blotches of shining pitch black, and numerous patches of yellow pyrites; in some parts imperfect casts of bi-valve shells and a fragment of vegetable charcoal. Generally scarcely soiling the hands. Over the spirit lamp it decrepitated somewhat, but did not swell up nor agglutinate.

No. 1255—COAL. *Labeled "Lower part of Payne and Berry's Coal, &c., &c."*

A bright pitch-black, pure coal; breaking easily. Fibrous coal, like the charred remains of reed leaves, between some of the layers; but the cleavage surfaces are generally glossy and irregular, with an approach to the bird-eye structure. No appearance of pyrites.

PROXIMATE ANALYSIS OF THESE TWO SPECIMENS.

	No. 1254. Upper part.
Moisture	2.00
Volatile combustible matters	35.40
Fixed carbon	37.30
Purplish-brown ashes	25.30
	100.000
Total volatile matters	37.40
Dense coke	62.60
Percentage of sulphur	16.142
Specific gravity	1.823

	No. 1255. Lower part.
Moisture	4.50
Volatile combustible matters	37.10
Fixed carbon	55.10
Dark purplish-grey ashes	3.30
	100.00
Total volatile matters	41.60
Light coke	58.40
Percentage of sulphur	3.262
Specific gravity	1.274

A marked difference will be seen in the composition and purity of these two samples.

COMPOSITION OF THE ASH OF NO. 1255, (LOWER PART.)

Silica	1.044
Alumina, and oxides of iron and manganese	2.080
Lime	.103
Magnesia	.133
Sulphuric acid	.066
	3.426

Traces of alkalies and phosphoric acid were present.

No. 1256—COAL. *Labeled "Cannel Coal, upper part, at Casey's mines, Union county, Ky."*

"A half inch layer of cannel coal with a quarter of an inch of pyritous bituminous shale above it, and bituminous coal under."

A dull black, tough, satiny looking coal. Over the spirit lamp, fragments swell very little, and do not agglutinate. Specific gravity 1.282.

PROXIMATE ANALYSIS.

Moisture	0.40	Total volatile matters	35.90
Volatile combustible matters	35.50		
Fixed carbon	48.20	Pretty dense coke	64.10
Light-grey ashes	15.90		
	100.00		100.00

The percentage of *sulphur* was found to be 1.017.

COMPOSITION OF THE ASH.

Silica	10.444
Alumina, and oxides of iron and manganese	4.138
Lime	trace.
Magnesia	.399
Phosphoric acid	.182
Sulphuric acid	.060
Alkalies and loss	.677
	15.900

The ash of this impure coal contains notable proportions of phosphoric acid and the alkalies.

No. 1257—COAL. *Labeled "Bird's-eye Coal, No. 10, or first coal at Curlew mines, Union county, Ky."*

A dull-black, tough cannel coal; with a curled-maple-like structure. The surface of the specimen, especially on the lines of cleavage, had become covered with effloresced sulphate of iron, although it had been kept in a comparatively dry room, warmed with a constant fire. Over the spirit lamp it softened and swelled very little; burnt with much smoky flame, leaving a pretty dense coke. Specific gravity 1.328.

PROXIMATE ANALYSIS.

Moisture	1.00	Total volatile matters	41.30
Volatile combustible matters	40.30		
Fixed carbon (in the coke)	44.30	Pretty dense coke	58.70
Grey-purple ashes	14.40		
	100.00		100.00

The percentage of *sulphur* was found to be 9.639.

COMPOSITION OF THE ASH.

Silica	2.784
Alumina, and oxides of iron and manganese	11.320
Lime	trace.
Magnesia	.299
Sulphuric acid	.201
Alkalies	not estimated.
	14.504

Submitted to destructive distillation for the production of oil, &c., it yielded the following products, viz:

Crude oil	190.0
Ammoniacal water	56.0
Coke	608.5
Combustible gases and loss	145.5
	1000.0

The gases from a thousand grains measured seven hundred and five cubic inches, and were not remarkable for illuminating powers. The remaining coke was porous and aggregated into a single mass. If the specimen tried is a fair sample of this coal, it does not promise much for the manufacture of coal oil. It, moreover, contains much more sulphur than the average.

No. 1258—COAL. *Labeled "Equivalent of Bell's Coal. Coal Company bank, town of Mulford, Union county, Ky."*

A deep pitch-black, somewhat brittle, shining, coal, cleaving into thin layers, with irregular shining surfaces, and little or no fibrous coal or pyrites. Exterior covered with orange colored, ochreous, oxide of iron. Over the spirit lamp it softened and agglutinated into a spongy coke. Specific gravity 1.295.

PROXIMATE ANALYSIS.

Moisture	1.34	Total combustible matters	37.30
Volatile combustible matters	35.96		
Fixed carbon (in the coke)	59.10	Spongy coke	62.70
Purplish-grey ashes	3.60		
	100.00		100.00

The percentage of *sulphur* was found to be 1.609.

COMPOSITION OF THE ASH.

Silica	1.384
Alumina, and oxides of iron and manganese	2.080
Lime	.271
Magnesia	.099
Alkalies and sulphuric acid	not estimated.
	3.834

A very good bituminous coal.

No. 1259—"FERRUGINOUS LIMESTONE, *fifteen to twenty inches thick, over the "Well" Coal, at Mulford's, Union county, Ky. How much iron?"*

A dull, greyish-black, fine-grained rock. Not adhering to the tongue. Powder mouse-colored. Specific gravity 2.686.

COMPOSITION, DRIED AT 212° F.

Carbonate of lime	47.380
Carbonate of magnesia	19.601
Carbonate of iron	13.556
Carbonate of manganese	.722
Alumina	4.000
Phosphoric acid	.848
Sulphuric acid	.222
Potash	.291
Soda	.160
Silex and insoluble silicates	7.280
Bituminous matters	6.160
	100.220

Contains too small a quantity of oxide of iron to be used as an ore for the production of that metal.

WOODFORD COUNTY.

No. 1260—"MINERAL WATER. *From a bored well, eighty-six feet deep, on the farm of Mr. Jno. H. Williams, three miles northeast of Versailles, Woodford county, Ky.*"

The water has a strong bituminous smell; and when evaporated to dryness at 212° F., left 3.555 per cent. of *saline matters;* the *composition* of which is as follows:

Carbonates of lime and magnesia	traces, not estimated
Chloride of sodium, (common salt)	2.340
Chloride of potassium	.014
Chloride of calcium	.325
Chloride of magnesium	.280
Sulphuric acid, Bromine, Alumina, silica, and loss	.596
	3.555

No. 1261—MINERAL WATER. "*From a bored well sixty feet deep, at Judge R. C. Grave's farm, Woodford county, Ky.*"

The recent water contains a little sulphuretted hydrogen; it contains a flocculent whitish sediment, which is composed of *sulphur*, mixed with *organic matter*, a little *carbonate of lime*, and a trace of oxide of iron.

When the water is boiled, it forms a considerable whitish deposit, composed of carbonate of lime, with some carbonate of magnesia. The remaining saline solution is *alkaline*, and contains carbonate of soda, with a little sulphate, and some chloride of sodium, with chloride of magnesium and a little chloride of calcium. The total saline matters amount only to 0.0285 per cent.

TABLE I. (B.) SOILS, SUB-SOILS, UNDER-CLAYS, AND MARLS. (*Coal Measures Formation.*)

Number in the report.	County.	Extracted from 1,000 grains by water charged with carb. acid.	Moisture expelled at 400 deg. F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
963	Estill	1.600	1.125	2.680	3.220	1.485	0.021	0.297	0.110	0.128	trace.	0.166	0.064	92.095	On millstone grit soil.
1025	Hancock	4.317	1.300	3.865	3.465	1.970	.170	.393	.233	.143	0.042	.150	.100	90.520	Ohio bottom soil.
1026	Hancock	1.590	0.923	2.019	3.390	2.690	.021	.439	.095	.190	.042	.181	.057	90.720	Ohio bottom sub-soil.
1027	Hancock	6.752	2.400	6.071	3.465	3.710	.346	.544	.095	.187	.050	.367	.077	84.945	Old field soil.
1028	Hancock	1.196	2.525	4.129	5.440	5.725	[illegible]	.797	.170	.145	.047	.391	.349	82.745	Sub-soil.
1029	Hancock	4.751	2.200	4.422	3.215	3.285	.171	.446	.241	.161	.059	.205	.040	88.130	Virgin soil, (woods.)
1030	Hancock	1.159	2.125	3.678	4.890	5.135	.071	.799	.120	.152	.016	.328	.051	84.720	Sub-soil.
1033	Hancock	3.250	1.475	4.729	2.115	1.900	.196	.408	.070	.185	.042	.212	.062	91.170	Soil.
1034	Hancock	1.800	1.850	3.642	5.390	6.400	.071	.585	.095	.151	not est.	.413	.131	83.320	Sub-soil.
1044	Hardin	1.538	1.475	3.197	2.015	2.035	.130	.472	.170	.072	.021	.164	.021	91.345	Old field, On oolitic limestone in mill. grit.
1045	Hardin	1.044	1.525	2.615	2.015	2.885	[illegible]	.411	.080	.072	.021	.169	.049	89.770	Sub-soil, On oolitic limestone in mill. grit.
1051	Hopkins	7.133	2.600	6.263	3.390	2.700	.445	.491	.295	.148	.076	.158	.034	85.970	Soil.
1052	Hopkins	2.983	1.900	4.295	4.845	2.910	[illegible]	.507	.370	.078	.059	.330	.113	86.070	Sub-soil.
1053	Hopkins	1.777	1.775	3.843	4.165	2.985	.095	.393	.280	.118	.025	.225	.090	87.945	Soil.
1054	Hopkins	0.850	2.150	3.756	5.890	4.700	.070	.584	.120	.096	.016	.323	.047	84.445	Sub-soil.
1055	Hopkins	2.570	1.300	2.887	3.415	2.385	.220	.344	.095	.173	.016	.198	.073	90.745	Soil.
1056	Hopkins	0.796	1.915	3.629	6.590	4.600	.045	.656	.170	.053	.033	.331	.067	84.445	Sub-soil, Top of the millstone grit.
1058	Jackson	2.450	1.915	4.998	5.560	2.970	.011	.444	.120	.126	.042	.243	.074	85.860	Virgin soil. Top of the millstone grit.
1059	Jackson	2.483	1.115	3.390	3.035	1.860	.031	.298	.045	.062	trace.	.232	.012	91.160	Old field soil. Top of the millstone grit.
1060	Jackson	1.500	0.965	2.433	5.583		.011	.117	------	.142	.016	.238	.079	90.995	Sub-soil. Top of the millstone grit.
1061	Jackson	3.833	1.850	4.737	9.210		.080	.306	------	.176	.050	.373	.085	84.620	Virgin soil. Slopes of the shales and sandstone.
1062	Jackson	4.750	2.500	6.425	6.320	3.360	.110	.529	.270	.194	.045	.306	.070	82.870	Old field soil. Slopes of the shales and sandstone.
1063	Jackson	2.283	2.035	4.812	6.870	3.710	.160	.456	.120	.160	.050	.521	.083	83.270	Sub-soil. Slopes of the shales and sandstone.
1156	Morgan	3.333	2.325	7.243	3.590	3.260	.320	.489	.195	.204	.067	.372	trace.	84.360	Virgin soil.
1157	Morgan	1.233	1.550	4.881	3.415	2.710	.145	.385	.070	.192	.050	.232	.018	88.595	Old field soil.

TABLE I. (C.) SOILS, SUB-SOILS, UNDER-CLAYS, &C., OF THE SUB-CARBONIFEROUS GROUP.

Number in the report.	County.	Extracted from 1,000 grains by water charged with carb. acid.	Moisture expelled at 400° F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
		(Grains.)													
812	Bath	3.077	1.425	4.251	1.515	2.210	0.195	0.329	0.130	0.095	0.033	0.130	0.050	91.095	Virgin soil. Sub-carboniferous sandstone.
813	Bath	1.757	0.975	3.105	1.340	3.710	.095	.295	.110	.127	.033	.110	.040	89.920	Old field.
814	Bath	1.483	0.650	2.164	1.415	4.435	.080	.362	.170	095	.028	.164	.018	92.270	Sub-soil.
815	Bath	4.935	3.025	8.198	5.490	3.360	.220	.488	.220	.179	.076	.210	.018	62.745	Old field soil.
816	Bath	1.339	1.750	5.038	6.927		.070	.500	------	.144	.033	.174	.119	86.995	Sub-soil.
817	Bath	5.733	3.350	10.527	4.240	2.210	.645	.405	.295	.223	.050	.212	.046	81.295	Sub-carb. limestone soil.
818	Bath	1.637	1.550	4.418	4.540	2.660	.160	.398	.415	.144	.025	.065	.161	87.720	Sub-soil of same.
837	Breckinr'ge	7.015	6.250	1.839	2.510		60.050	.101	------	.030	.084	.217	.061	34.580	Disintegrated limestone.
839	Breckinr'ge	6.823	4.000	8.411	5.240	4.838	1.880	.830	.345	.130	.076	.434	.099	77.495	Virgin soil.
840	Breckinr'ge	1.300	3.000	4.407	6.590	4.460	.570	.559	.120	.152	.016	.378	.178	82.270	Sub-soil.
841	Breckinr'ge	2.350	1.775	5.141	2.315	2.535	.420	.366	.120	.160	.059	.118	.032	88.120	Virgin soil.
842	Breckinr'ge	1.117	1.975	3.513	3.740	3.970	.195	.474	.195	.094	.033	.198	.078	87.120	Sub-soil.
843	Breckinr'ge	1.466	1.425	2.942	3.215	2.335	.145	.488	.095	.065	.028	.183	.050	90.930	Old field soil.
844	Breckinr'ge	1.149	2.825	3.678	5.165	5.085	.220	.542	.070	.095	.033	.347	.113	83.720	Sub-soil.
845	Breckinr'ge	2.700	2.650	5.136	2.615	2.935	.170	.345	.195	.095	.055	.119	.033	87.645	Soil.
846	Breckinr'ge	0.823	2.350	3.609	5.315	4.010	.110	.392	.170	.095	.041	.327	.041	85.220	Sub-soil.
848	Bullitt	2.684	2.075	5.159	3.540	3.875	.210	.416	.071	.209	.059	.256	.037	86.070	Virgin soil.
849	Bullitt	2.803	1.800	5.142	3.515	3.125	.271	.431	.121	.150	.065	.217	.062	87.345	Old garden soil.
850	Bullitt	1.105	2.550	3.591	6.440	4.840	.170	.562	.070	.127	.033	.278	.005	84.110	Sub-soil.
851	Bullitt	5.370	2.465	7.033	3.840	5.840	1.621	1.643	.110	.281	.050	.211	.170	80.220	Virgin soil (bottom.)
852	Bullitt	2.725	2.725	3.675	2.390	3.290	a trace	.451	.145	.129	not est.	.125	.040	88.745	Virgin soil (hill top.)
853	Bullitt	2.830	3.525	5.827	4.065	4.165	.395	.828	.145	.159	not est.	.0-2	.132	84.395	Old field soil.
854	Bullitt	0.736	3.100	3.261	6.290	5.390	a trace	.569	.195	.094	not est.	.477	.081	83.395	Sub-soil soil.
960	Estill	4.066	3.510	8.483	6.750	3.210	.030	.460	.460	.318	.055	.408	.068	79.695	Virgin soil.
961	Estill	4.077	2.100	4.647	4.535	2.270	.181	.451	.310	.274	.033	.296	.085	86.610	Old field soil.
962	Estill	1.533	1.615	2.957	5.110	2.910	.096	.417	.180	.192	.016	.316	.093	87.970	Sub-soil.
1040	Hardin	2.823	2.100	5.207	2.990	2.235	.370	.392	.320	.183	.040	.169	.042	88.130	Virgin soil.
1041	Hardin	0.850	1.750	2.865	3.540	3.260	.245	.483	.245	.078	.057	.183	.063	87.570	Sub-soil.

TABLE I. (C.) SOILS, &c., &c.—Continued.

Number in the report.	County.	Extracted from ,000 grains by water charged with carb acid.	Moisture expelled at 400° F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
1042	Hardin......	1.917	1.265	3.378	3.020	2.260	0.245	0.321	0.120	0.137	0.041	0.121	0.040	90.228	Old field soil.
1043	Hardin......	1.078	1.425	2.561	2.990	2.535	.170	.315	.195	.119	.028	.101	trace.	90.495	Sub-soil.
1222	Rowan......	2.161	1.650	5.461	3.490	3.085	.220	.311	.195	.078	.110	.400	.022	86.520	Virgin soil. } Knob formation.
1223	Rowan......	1.928	1.250	3.797	3.165	1.685	.195	.279	.060	.095	.028	.191	.025	90.420	Old field soil. } Knob formation.

TABLE I. (D.) SOILS, SUB-SOILS, UNDER-CLAYS, AND MARLS. (*Devonian Formation.*)

Number in the report.	County.	Dissolved from 1,000 grains by water charged with carb. cid	Moisture expelled at 400° F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
884	Clarke.....	3.777	3.750	7.195	5.615	6.635	0.120	0.948	0.220	0.346	0.050	0.580	0.409	78.470	Virgin soil (Indian old fields.)
885	Clarke.....	5.790	5.000	6.842	5.690	9.535	.020	.772	.145	.384	.127	.265	.122	75.170	Old field soil (Ind. old fields.)
886	Clarke.....	1.893	5.275	9. 63	6.815	12.510	.345	.855	.170	.217	.067	.463	.088	69.220	Sub-soil (Indian old fields.)
958	Estill......	3.057	4.275	10.942	3.290	6.635	.420	.392	.145	.147	.578	.697	.309	74.895	Cultivated field.
1125	Madison	1.731	2.450	6.125	2.215	11.015	.095	.385	not est.	.271	not est.	.121	.039	79.270	Virgin soil (on Dev'n slate.)
1127	Madison	9.550	6.150	15.450	3.565	5.560	1.295	.750	.270	.253	.120	.753	.123	71.045	Virgin "Red Bud" soil.
1128	Madison	3.600	4.035	8.508	6.240	6.835	.470	1.041	.245	.214	.059	.796	.097	75.620	Old field "Red Bud" soil.
1129	Madison	3.743	4.535	7.584	5.900	6.360	.770	.960	.320	.199	.085	.705	.231	76.745	Sub-soil "Red Bud."
1179	Nelson	3.528	3.375	9.656	2.305	3.285	.396	.643	.310	.378	.076	.135	.046	82.870	Virgin soil.
1180	Nelson	1.433	1.950	3.809	3.990	3.910	.172	1.328	.310	.161	.127	.175	.038	86.520	Sub-soil.
1181	Nelson	1.564	1.885	4.586	2.990	4.215	.196	1.214	.220	.208	.050	.169	.045	87.145	Old field soil.
1182	Nelson	1.045	2.250	3.785	4.590	5.800	.146	1.273	.245	.162	.059	.206	.046	84.895	Sub-soil.
1183	Nelson	2.257	[illegible]	5.149	2.390	[illegible]	.221	.503	.195	.161	.084	.181	.047	85.840	Old field soil.
1184	Nelson	1.819	2.775	4.705	4.715	5.035	.246	.536	.120	.242	.050	.227	.061	83.495	Sub-soil.
1185	Nelson	2.117	3.225	4.521	3.749	2.860	.196	.337	.195	.031	.067	.164	.031	87.570	Virgin soil.
1186	Nelson	1.022	2.425	2.231	4.155	3.410	.071	.423	.160	.096	.041	.104	.082	87.845	Sub-soil.
1187	Nelson	2.890	3.775	5.326	2.490	4.570	.371	.545	.170	.247	.067	.246	.059	85.195	Soil.
1188	Nelson	2.467	5.275	4.355	8.140	6.885	.422	.736	.170	.216	.050	.743	.066	78.170	Sub-soil.
1189	Nelson	....	.....	......	12.960	6.740	12.380	.389	.[illegible]84	.25[illegible]	not est.	2.843	not est.	52.680	White under-clay (marl.)
1190	Nelson	....	.....	......	15.348	12.940	1.980	1.216	.284	1.088	not est.	1.371	.122	54.280	Ferruginous under-clay.
1191	Nelson	6.500	7.825	10.425	3.490	11.385	6.146	5.710	.145	.275	.058	.420	.099	61.495	Virgin soil } Partly from
1192	Nelson	2.577	9.375	6.207	10.590	13.585	.770	1.010	.045	.167	.050	.700	.083	64.820	Sub-soil. } *Upper Silurian.*
1193	Nelson	1.826	2.695	3.286	1.190	3.670	.172	.415	.228	.047	.050	.164	.034	89.045	Old field soil.
1194	Nelson	1.144	3.475	2.564	5.890	5.135	.220	.584	.170	.079	.058	.357	.042	84.820	Sub-soil.
1215	Powell	3.1 5	2.900	8.033	3.215	4.885	.095	.581	.130	.278	.278	.579	.031	81.795	Virgin soil. } From
1216	Powell	1.903	2.000	5.120	4.300	5.2[illegible]5	.070	.420	.290	.174	.110	.290	.187	83.[illegible]21	Old field soil } the black
1217	Powell	1.326	1.815	3.625	4.690	5.885	.020	.540	.145	.145	.067	.350	.067	83.943	Sub-soil. } shale.

TABLE I. (E.) SOILS, SUB-SOILS, UNDER-CLAYS, AND MARLS. (*Upper Silurian Formation.*)

Number in the report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture expelled at 400° F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
905	Bath	3.050	3.650	8.165	4.565	6.960	0.570	0.710	not est.	0.174	not est.	0.290	0.059	79.145	Virgin (Clinton group) soil.
906	Bath	2.717	3.450	7.639	5. 91	7.88	.420	.615	not est.	.246	not est.	.249	.073	78.270	Old field (Clinton group) soil.
907	Bath	2.103	2.475	5.024	4.5 5	3.535	.095	.385	0.220	.118	0.041	.246	.100	86.980	Virgin (Clinton group) soil
908	Bath	2.552	2.600	5.118	5.115	5.157	.170	.524	.220	.284	.058	.210	.048	83.320	Old field (Clinton group) soil.
1069	Jefferson	------	------	2.196	7.260		26.880	1.687	------	.694	.406	.965	.012	59.900	Marl (Chenowith creek.)
1070	Jefferson	2.783	2.100	5.173	2.900	3.085	.370	.719	.395	.203	.076	.208	.154	86.370	Virgin soil (Beargrass.)
1071	Jefferson	1.480	1.650	3.417	3.665	3.410	.270	.621	.270	.127	.042	.212	.077	87.995	Sub-soil of same.
1072	Jefferson	3.066	1.975	5.457	2.765	2.510	.370	.467	.320	.169	.059	.167	.072	87.170	Old field soil (Beargrass.)
1073	Jefferson	1.500	1.650	3.4 6	3.365	3.410	.290	.576	.220	.127	.025	.257	.127	87.795	Sub-soil of same.
1074	Jefferson	2.120	1.685	4.389	2.890	2.985	.270	.484	.245	.258	.067	.253	.026	87.345	70 years old field (Beargrass.)
1075	Jefferson	1.055	1.775	3.105	4.115	3.320	.245	.513	.220	.176	.041	.275	.047	87.870	Sub-soil of same.
1076	Jefferson	7.766	------	8.294	19.310		2.595	.071	------	.269	.062	.874	.090	68.820	Marl in the lime-rock.
1087	Lewis	1.833	2.065	4.809	2.595	4.495	.221	.542	.220	.112	.045	.338	.050	86.495	Yellow mag. limestone soil.
1088	Lewis	2.659	2.125	5.915	1.865	2.740	.245	.426	.045	.144	.050	.159	.005	88.295	Virgin soil mag. limestone.
1089	Lewis	2.9 6	1.851	4.613	1.990	3.510	.195	.426	.120	.118	.042	.130	.063	87.470	Old field soil mag. limestone.
1090	Lewis	1.695	1.835	4.403	4.640	3.585	.230	.475	.045	.162	.011	.195	.127	87.120	Sub soil of same.
1169	Nelson	5.655	3.210	7.351	4.990	4.015	.171	.691	.495	.331	.164	.269	.017	82.395	Soil.
1170	Nelson	1.460	2.100	2.982	6.125	4.925	.045	.637	.420	.145	.033	.381	.062	83.470	Sub soil.
1171	[illegible]	4.549	3.610	7.563	4.850	5.425	.411	.702	.720	.272	.036	.452	.040	79.295	Soil.
1172	Nelson	2.100	3.225	5.812	6.649	6.414	.311	.692	.870	.142	.050	.247	.049	78.795	Sub-soil.
1173	Nelson	5.300	4.875	9.975	8.740	12.675	3.221	2.878	.620	.149	.041	.348	.297	61.095	Under-clay.
1174	[illegible]	2.117	2.300	4.886	4. 30	3.865	.270	.455	.324	.144	.065	.290	.062	85.895	Old field soil.
1175	Nelson	1.833	3.225	4.665	6.990	6.415	.196	.982	.145	.113	.040	.410	.139	80.495	Sub-soil.

TABLE I. (F.) SOILS, SUB-SOILS, UNDER-CLAYS, AND MARLS. (*Lower Silurian Formation.*)

Number in the report.	County.	Dissolved from 1,000 grains by water charged with carb acid.	Moisture expelled at 400° F.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Remarks.
804	Bath	5.150	4.500	9.527	3.990	4.235	0.620	0.700	not est.	0.415	not est.	0.290	0.054	80.190	Best hemp soil of Bath co.
809	Bath	6.400	4.200	8.376	5.115	2.185	.580	.660	0.195	.365	0.084	.372	.123	82.595	Virgin soil.
810	Bath	3.694	3.300	6.308	5.265	4.235	.445	.617	.295	.296	.067	.280	.044	82.270	Old field soil.
811	Bath	1.881	2.650	4.108	5.490	4.235	.370	.613	.295	.312	.055	.367	.037	84 920	Sub-soil.
826	Bracken	9.861	6.975	7.981	6.645	6.825	1.586	1.354	.296	.342	110	.758	.047	72.920	Virgin tobacco soil.
827	Bracken	1.454	2.950	4.853	3.680	5.540	.396	.844	.146	.179	.031	.458	not est.	83.310	Sub-soil.
828	Bracken	3.333	2.525	5.489	4.080	3.215	.471	.762	.196	.268	.042	.265	.029	85.300	Exhausted tobacco soil.
829	Bracken	4.330	3.675	7.412	5.990	6.975	.871	1.623	.260	.289	.033	1.164	.058	74.895	Vineyard soil.
830	Bracken	3.670	1.635	3.497	3.360	4 095	.495	.593	.145	.225	.045	.319	.029	86.970	Under-clay (contains bones.)
831	Bracken	2.017	2.200	5.931	4.115	3.435	.170	.836	not est.	.254	not est.	.190	.034	84.695	Virgin soil.
832	Bracken	1.390	2 525	3.795	3.465	3.210	.220	.869	not est.	.227	not est.	.237	.089	87.070	Old field soil.
878	Clarke	5.633	4.750	9.028	6.565	5.600	.545	.687	.545	366	.084	.475	.124	76.070	Virgin soil
879	Clarke	3.600	3.125	6.379	4.240	4.960	.695	.563	.320	.211	.084	.296	.056	81.920	Old field soil.
880	Clarke	2 400	3.400	5 797	7.165	5.460	.320	.859	.370	.228	.050	.583	.053	79.620	Sub soil.
881	Clarke	2 633	4.050	7.764	6.790	5.860	.345	.883	.330	.306	.092	.589	.005	76.820	Virgin soil.
882	Clarke	1.917	3.350	5.985	6.240	5.785	.195	.719	.320	.245	.067	.396	.034	79.945	Old field soil.
883	Clarke	2.194	3.350	5.923	6.290	5.865	.195	1.133	.395	.296	.076	.507	.065	79.970	Sub-soil.
971	Fayette			*5.676	24.656		2 480	†3.276		.182		6.655	.195	56.880	Marly clay (Brink's branch.)
972	Fleming		1.200	*13.900	10.401	10.760	16.830	‡6.385	1.084	.079	.338	1.147	not est.	39.780	Marl (junc. Upper Silurian.)
975	Fleming	4.250	5 525	11.315	5.060	11.675	.420	.874	.290	.251	.084	.349	.224	69.145	Virgin soil. Junction of
976	Fleming	2.523	4 225	7.335	4.190	11.210	.395	.679	.395	.181	.042	.202	.011	75.645	Old field soil. Upper and
977	Fleming	2.082	6 650	7.675	10 335	14.930	.470	.868	.370	.236	.059	.439	.050	64.995	Sub soil. Low'r Silur'n.
978	Fleming	4.566	4.675	8.523	6.840	5.760	.870	.798	.170	.228	.075	.526	.128	76.445	Virgin soil (blue limestone.)
979	Fleming	2.850	3.100	5.211	5 275	5.510	.370	.736	.270	.409	.093	.468	.043	80.945	Old field soil.
980	Fleming	2.079	2.875	4.135	6 265	6.035	.395	.580	.095	.223	.058	.700	.168	80.745	Sub soil.
982	Franklin	2.076	2.700	6 372	4.185	4.310	.320	.563	.320	.350	.076	.222	.052	82.270	Virgin soil.
983	Franklin	2.896	2.400	6 147	5.435	4 560	.320	.801	.445	.270	.076	.288	.058	81.470	Old field soil.
984	Franklin	2.054	2.125	4.281	5.035	4.765	.520	.526	.095	.553	.050	.290	.073	83.445	Sub-soil.

986	Garrard	1.400	2.400	4.200	3.790	3.310	0.170	0.506	0.295	0.243	0.096	0.135	0.032	87.670	Woodland soil.	On the bird's-eye limestone.
987	Garrard	1.133	2.460	2.988	4.840	3.970	.120	.540	.245	.260	.024	.237	.026	86.645	Sub-soil.	
988	Garrard	2.383	2.725	5.294	5.090	3.910	.110	.973	.245	.244	.050	.190	.026	82.945	Old field soil.	
989	Garrard	1.974	2.525	3.411	13.635		2.470	.325	------	.249	.059	.347	.092	79.960	Sub-soil.	
990	Grant	-------	-------	-------	16.250		4.980	†3.285	------	.310	1.197	.988	.178	71.280	Marl, in blue limestone.	
1130	Mason	-------	-------	-------	8.020		7.380	3.105	------	1.040	.592	.722	.172	78.180	Marl, in blue limestone.	
1134	Mason	4.570	4.175	8.462	4.745	6.240	.836	.798	.146	.231	.084	.558	.160	78.100	Virgin tobacco soil.	
1135	Mason	3.746	3.265	6.445	3.730	4.465	.476	.807	.221	.212	.042	.418	.023	83.330	Old field soil.	
1136	Mason	3.337	3.050	5.931	4.390	4.090	.497	.618	.196	.245	.059	.475	.079	83.130	Sub-soil.	
1139	Mercer	6.810	4.300	5.564	5.090	4.115	.495	.732	.120	.323	not est.	.366	.143	83.295	Virgin soil.	
1140	Mercer	0.804	4.000	3.413	6.715	4.990	.245	.828	.120	.243	not est.	.421	.019	82.695	Sub-soil.	
1141	Mercer	2.650	3.750	4.805	4.595	4.740	.320	.811	.120	.288	.042	.140	.108	83.625	Old field soil.	
1142	Mercer	1.547	3.150	3.289	5.840	5.115	.220	.887	.220	.345	not est.	.290	.035	83.945	Sub-soil.	
1144	Mercer	2.788	2.600	5.703	3.015	3.210	.345	.512	.070	.096	.028	.172	.068	86.570	Virgin soil.	Oak region of Mercer county.
1145	Mercer	2.450	3.115	5.707	5.665	4.100	.420	.553	.240	.096	.016	.183	.015	82.660	Sub-soil.	
1146	Mercer	3.090	2.450	5.049	3.240	3.710	.320	.612	.245	.128	.024	.203	.108	86.145	Old field soil.	
1147	Mercer	1.757	5.525	6.747	14.360		.360	.460	------	.138	.042	.237	.057	77.570	Sub-soil.	
1148	Montgomery	5.076	3.725	6.751	4.690	5.810	.420	.677	.245	.313	.076	.410	.245	80.095	Virgin soil.	
1149	Montgomery	2.435	3.600	6.172	5.440	4.710	.420	.583	.120	.345	.067	.331	.133	81.470	Old field soil.	
1150	Montgomery	1.407	2.900	4.171	6.590	6.235	.220	.634	.295	.257	.041	.372	.139	81.370	Sub-soil.	
1151	Montgomery	0.899	3.525	4.378	7.400	11.100	.095	.235	.495	.395	.024	.280	.104	72.670	Under-clay.	
1196	Nicholas	3.543	2.500	7.820	4.360	4.465	.520	.706	.320	.211	.058	.365	.131	81.120	Virgin soil.	
1197	Nicholas	1.933	2.600	6.339	6.260	5.970	.345	.643	.270	.195	.050	.336	.071	79.720	Old field soil.	
1198	Nicholas	1.280	4.150	6.687	11.235	7.987	.370	.851	.095	.231	.016	.485	.078	71.870	Sub-soil.	
1203	Owen	-------	-------	‡8.998	19.940		34.580	†5.287	------	.934	.372	.649	------	29.240	Marl from milk-sick district.	
1204	Owen	1.770	2.375	4.865	2.695	2.810	trace.	.514	.095	.086	.050	.094	.035	88.020	Virgin soil.	White oak and beech land on the silicious mud-stone.
1205	Owen	2.470	2.925	6.026	3.470	3.935	trace.	.915	.170	.178	.050	.089	.040	84.870	Old field soil.	
1206	Owen	1.217	2.775	4.319	5.280	5.260	trace.	1.178	.220	.128	.033	.271	.098	82.820	Sub-soil.	
1207	Owen	1.450	2.515	4.112	2.545	2.995	.305	.686	.171	.144	.045	.116	.022	88.120	Virgin soil.	
1208	Owen	1.853	2.750	5.218	3.160	3.365	.120	.708	.445	.210	.062	.149	.049	85.970	Old field soil.	
1209	Owen	1.630	2.525	3.890	3.695	3.735	.095	.746	.695	.227	.058	.133	.042	87.295	Sub-soil.	

* Water. † Carbonate. ‡ Magnesia.

TABLE II. LIMESTONES.

Number in the report.	County.	Specific gravity.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of iron.	Carbonate of manganese.	Alumina.	Oxide of iron.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Silica, &c.	Lime.	Magnesia.	Remarks.
796	Bath..........	2.704	52.240	18.531	.....	.....	0.620	8.120	0.380	0.117	0.633	0.444	0.212	17.540	29.877	8.828	Hydraulic.
797	Bath.........	.....	51.540	29.779	3.095	0.752	.290	10.627	.....	.502	.235	.209	trace.	1.980	28.590	13.700	Clinton group.
822	Bourbon......	.....	75.960	15.395	......	......		4.080		.822	.427	.165	.042	2.640	43.837	7.436	Lower Silurian.
825	Bracken......	......	91.040	3.078	......	......		1.060		.182	.209	.200	.148	2.890	51.024	......	Lower Silurian.
838	Breckinridge	.....	80.080	1.443	......	......		1.580		trace.	.166	.398	.100	15.580	......	......	Sub carboniferous.
853	Bullitt......	......	50.980	37.747	......	......		2.780		trace.	not est.	.463	.298	6.380	......	......	Upper Silurian.
857	Bullitt.......	.....	52.880	37.577	......	......		1.640		trace.	.067	.270	.198	5.980	......	......	Upper Silurian.
858	Bullitt.	......	93.000	3.314	......	......		.780		trace.	not est.	.297	.090	1.980	......	......	Sub-carboniferous.
868	Carter........	2.782	50.780	3.990	......	......	0.660	3.164	20.960	.950	.475	.132	.067	1.880	......	......	Star Furnace.
876	Clarke........	2.735	60.640	32.500	......	......		0.580		.907	.124	.374	.250	3.530	34.028	15.040	Lower Silurian.
877	Clarke........	.....	85.530	3.367	......	......		3.290		.118	.474	.422	.462	5.920	48.017	......	Lower Silurian.
888	Clarke........	.....	40.280	15.913	......	......		9.460		....	1.055	.436	.164	23.180	......	......	Devonian (hydraulic?)
897	Crittenden ..	2.719	52.880	25.254	......	......		1.400		.008	.013	.394	.253	18.880	......	......	Crittenden Furnace.
898	Crittenden ..	2.733	55.290	29.246	......	......		1.323		.117	trace.	.344	.156	14.280	......	......	Crittenden Furnace
915	Crittenden ...	.....	79.340	8.468	......	......		2.580		trace.	.547	.353	.133	7.540	30.158	......	Hurricane Furnace.
930	Daviess......	......	38.960	10.685	......	......		10.440		.967	3.153	.366	.063	28.280	......	......	Sub-carboniferous (hydraulic?)
939	Estill	2.693	92.020	.029	......	......		1.120		.310	.106	.193	.063	4.580	50.515	......	Sub-carboniferous.
947	Estill..........	......	41.380	30.019	4.321	......	0.806	2.360	0.480	.374	1.471	.468	.019	18.080	23.221	......	Upper Silurian (hydraulic?)
949	Estill.........	2.716	27.960	19.422	......	......		9.080		.246	.544	.618	.306	38.480	......	......	Hydraulic.
950	Estill.........	......	37.460	22.927	......	......		6.100		.182	1.368	.695	.379	28.580	......	......	Hydraulic.
951	Estill.........	......	36.540	19.792	......	......		6.200		.079	1.551	.462	.231	28.240	......	......	Hydraulic.
955	Fayette......	......	92.640	3.988	......	......		.440		trace.	.441	not es	not es	2.480	......	......	Lower Silurian.
957	Fayette......	......	77.060	15.426	......	......		1.990		.246	.166	.193	.363	2.080	......	......	Lower Silurian (Raven creek.)
958	Fayette......	......	95.680	2.144	......	......		.380		.169	.160	.193	.049	1.580	......	......	Lower Silurian (Bird's-eye marb.)
9	Fayette......	......	62.680	23.079	......	......		6.080		.246	.441	.169	.192	5.280	......	......	Lower Silurian (Ky. marble.)
970	Fayette......	......	91.480	1.644	......	......		3.980		.049	.317	.232	.331	2.380	......	......	Lower Silurian (coarse grained.)
973	Fleming......	......	42.080	25.358	5.155	.421	1.080	11.073	......	.846	.324	.298	.033	10.880	23.051	......	Clinton group (hydraulic?)
974	Fleming......	......	71.700	9.531	......	......		12.140		.030	.337	.341	.139	2.880	......	......	Clinton group.
971	Franklin	......	93.580	3.003	......	......		.980		.117	.441	.057	.105	.380	52.663	......	Lower Silurian.
985	Garrard	......	34.780	21.470	......	......		5.900		.310	.956	.471	.130	35.190	......	......	Upper Silurian (hydraulic?)
998	Grayson	......	85.080	2.553	......	......		2.560		.188	.839	.259	trace.	7.480	......	......	Sub-carboniferous.
1009	Greenup......	2.706	94.980	1.523	......	......		.580		trace.	.317	.318	.140	2.080	53.298	......	Sub-carboniferous (Kenton Fur.)

1013	Greenup	2 836	65.280	4 346	28.841		2?0 ...... 0.380	trace.	1.196	0.027	0.101	.380			Ferruginous (Steam Furnace.)
1037	Hardin		73.180	11.469			0 880	.150	.338	.173	.098	6.980			Sub-carboniferous.
1038	Hardin		82.280	7.310			.060	.18	.417	.390	.090	9.220			Sub-carboniferous.
1039	Hardin		98.580	.620			.400	.193	.274	.154	.022	380			Sub-carboniferous ("Oolitic.")
1046	Henderson		88 380	3.678			1.760	.246	.180	.249	.068	3.280			Coal Measures.
1065	Jefferson		52 480	31.473			4.473	.208	.303	.646	307	10.480			Upper Silurian.
1066	Jefferson		42.980	21.819			6.500	.214	1.284	.233	.372	23.980	24.118	10.305	Upper Silurian (hydraulic
1067	Jefferson		*30 980				10.400	.158	not est.	.214	.672	17.720	28.260	11.065	Old hydraulic cement.
1068	Jefferson		45 880	22 911			5.760	.220	269	347	.372	21 523	25 746	10.514	Madison, Indiana.
1068a							14.900	not est.	not est.	not es	not es	29 040	38.718	15.337	Same after calcination.
1077	Jefferson		80 460	6.783			1.480	.310	.475	.154	163	2.680			Upper Silurian or Devonian.
1078	Jefferson		92 560	4.613			.480	trace.	.166	.166	.074	2.580			Upper Silurian or Devonian.
1079	Jefferson		82.960	14.614			.880	182	.272	013	.212	.880			Upper Silurian or Devonian.
1080	Jefferson		88.600	7.463			.208	.669	.647	.252	not es	1 680			Upper Silurian or Devonian.
1081	Jefferson		86 260	587			.580	tr. ce.	132	.115	.116	9.580			Upper Silurian or Devonian.
1084	Lewis	2.687	42.480	15.925	0.692	0.571	3·1 0 446	.162	.132	.560	326	23 380			Concretion in shale.
1085	Lewis		55 240	27.820			12.980	.207	.152	167	.136	2.580			Upper Silurian.
1094	Livingston		91.680	3.108			.284	trace.	.372	.224	.124	4 280	51 447		Sub carboniferous?
1108	Lyon		86.380	.542			1 160	.062	887	not es	not es	8 680	54.084		Mammoth Furnace.
1116	Lyon		73.580	17.485			2.240	.079	.558	not es	not es	4 880	41 290		Suwannee Furnace.
1123	Madison		49.320	30.729			2 860	.271	.549	.374	.058	14 180			Upper Silurian (hydraulic?)
1131	Mason		75 440	4.783			3.751	.409	.474	.540	202	14 440			Lower Silurian.
1132	Mason		87.980	1.721			2 280	.348	.372	.209	.147	4.380			Lower Silurian.
1133	Mason		77.760	2 307			3 910	.310	2.433	.424	.008	13 080			Lower Silurian.
1137	Meade		47.330	26.515			2.100		1.332	.126	.265	19 040	26.088	12.631	Hydraulic.
1138	Meade		28.360	17.771			2.680		2.767	.115	110	47 980	15.974	8.460	Hydraulic.
1143	Mercer		90.720	4 615			2.700	.146	not est.	.328	.021	1.880			Lower Silurian.
1165	Nelson		40.480	24 267			4.493	.207	.819	.455	.042	29.380			Upper Silurian (hydraulic?)
1166a	Nelson		49.780	34.456			3.600	.246	.475	270	.000	10.780			Upper Silurian (hydraulic)
1166b	Nelson		48.280	34.100			2.980	.118	.386	not es	not es	11.480			Upper Silurian (hydraulic)
1167	Nelson		50.480	38 154			2.140	.118	.280	.258	.260	8.380			Upper Silurian (hydraulic)
1168	Nelson		94 380	2.419			.660	.117	.338	.193		1.980			Upper Silurian (fossil coral.)
1176	Nelson		54.080	30.562			2.980	.054	.111	.231	.240	880			Upper Silurian.
1177	Nelson		48.080	29 660			9.780	trace.	trace	.533	.134	11 .580			Upper Silurian.
1178	Nelson		93.980	2.707			264	.054	238	.189	trace.	3 040			Upper Silurian.
1201	Oldham		41 580	24 630			5.860	374	313	.455	.264	23 580			Upper Silurian (hydraulic?)
1202	Oldham		41 980	21.400			8.860	.310	.346	.370	379	24.080			Upper Silurian (hydraulic?)
1228	Trigg		13.040	1 150			2.080	none.	.242	.193	.170	1.980	58.210		Empire Furnace.
1236	Trigg		94 940	1 958			.280	.158	not est.	.181	.166	2.840			Centre Furnace
1240	Trigg		88 180	4.335			.280	tr. e .	.180	.151	.154	9 520	?.487		Fulton Furnace (grey)
1247	Trigg		69 080	2.168			2 480	.335	.532	.355	232	21 840	. 64		Fulton Furnace (black)
1251	Trimble		94.880	1.119			.680	.639	.200	.163	.092	2 480			Fossil Murchisonia.
1259	Union	2.049	47.380	19.609	13.550	0.722	4 000	.848	.222	.391	160	7.280	Bit. &c.=6160.		Mulford's.

* Carbonic acid=22.140. Combined water=10.348.

TABLE III. (A.) IRON ORES. (*Limonites.*)

Number in the report.	County.	Oxide of iron.	Alumina.	Carbonate of lime.	Magnesia.	Brown oxide of manganese	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Combined water.	Silex, &c.	Percentage of iron.	Remarks.
777	Bath	76.680	0.440	none.	0.685	0.580	0.886	0.235	0.358	0.197	11.200	8.080	53.400	Slate Furnace ore.
778	Bath	76.774	.800	none.	1.018	.680	1.206	.221	.258	.202	11.760	7.280	53.766	Slate Furnace ore.
779	Bath	52.660	2.642	trace.	.781	.580	.438	.235	.509	.230	9.300	32.780	36.878	Slate Furnace ore.
780	Bath	80.520	3.482	none.	.558	.220	.758	.201	.386	.132	10.900	3.280	56.369	From Wickliffe bank.
782	Bath	82.120	.820	trace.	1.010	1.340	.220	.386	.193	.180	5.420	8.980	57.510	Clear Creek Furnace.
783	Bath	70.935	.900	trace.	1.129	1.780	.505	.290	.291	.180	5.400	18.640	49.677	Clear Creek Furnace.
784	Bath	72.886	.980	trace.	.551	.380	.694	.283	.321	.048	12.200	11.880	51.043	Clear Creek Furnace.
785	Bath	68.140	2.733	trace.	1.171	1.680	.247	.336	.413	.132	9.040	16.080	47.719	Clear Creek Fur. (Jones' bank.)
786	Bath	64.306	3.080	trace.	1.003	2.440	.374	.290	.703	.312	6.200	21.407	45.034	Clear Creek Furnace.
790	Bath	86.268	.480	trace.	.840	3.580	.272	.303	.220	.123	6.000	2.120	60.415	Clear Creek Furnace.
791	Bath	65.400	4.366	trace.	.932	.580	1.014	.234	.656	.245	12.100	15.080	45.800	Clear Creek Furnace.
792	Bath	77.580	1.600	trace.	.504	.580	.720	.204	.386	.260	11.500	7.040	54.330	Clear Creek Furnace.
793	Bath	69.940	3.297	6.504	2.556	1.580	1.783	.267	.328	.202	6.200	7.980	48.980	Clear Creek Furnace.
794	Bath	38.000	3.265	1.284	1.565	.780	1.015	.853	.583	.147	7.900	44.880	26.612	Clear Creek Furnace.
859	Campbell ..	16.600	6.920	.980	2.396	3.480	.950	.269	.596	.003	6.500	61.280	--------	Yeton Farm bog iron ore.
860	Carter	69.740	1.680	trace.	1.114	1.780	.335	.272	.270	trace.	12.800	11.680	48.840	Star Furnace (Red Kidney Ore.)
861	Carter	43.780	1.380	17.680	3.022	1.880	2.293	.460	.374	.025	9.726	19.380	30.666	Star Furnace (Lim. Ore No. 5.)
862	Carter	39.440	.280	1.800	.836	39.677	2.101	not est.	.270	.039	14.300	1.380	27.620	Star Furnace (Block Ore.)
863	Carter	70.872	.720	trace.	.999	1.280	1.268	.647	.386	.132	10.500	12.980	49.633	Star Furnace (Yel. Kidney Ore.)
864	Carter	68.880	.980	6.880	2.444	.380	1.140	.681	.231	.057	6.700	10.840	48.238	Star Furnace (Lim. Ore No. 8.)
887	Clarke.....	66.060		.084	.266	------	1.015	.132	.349	.181	12.873	19.040	--------	Iron Gravel (Indian old fields.)
891	Crittenden .	78.140	.580	trace.	.680	.580	.502	.133	.328	.014	11.000	7 780	54.722	Crittenden Furnace "Pipe Ore."
892	Crittenden .	80.940	.580	trace.	.474	.380	.502	.201	.328	.202	5.300	11.520	56.684	Crittenden Furnace "Pot Ore."
893	Crittenden .	81.000	.580	trace.	.796	.180	.886	trace.	.320	.150	10.900	5.180	56.725	Crittenden Furnace "Block Ore."
894	Crittenden .	72.140	.480	trace.	.308	.880	.438	.166	.417	.180	10.200	16.980	50.521	Crittenden Furnace "Brown Ore."
895	Crittenden .	81.340	1.340	trace.	.503	.360	1.204	.132	.181	.064	11.140	4.380	56.954	Critt. Fur. "Honey-comb Ore."
909	Crittenden .	80.940	.420	trace.	.713	.280	.438	.200	.200	trace.	10.000	7.380	56.684	Hurricane Furnace "Block Ore."
910	Crittenden .	56.840	8.980	trace.	.936	.320	.591	.040	.301	trace.	11.600	20.880	39.806	Hurricane Fur. Honey-comb Ore."
911	Crittenden .	82.540	.580	trace.	.541	.240	.502	.083	.162	.076	10.560	5.380	58.014	Hurricane Furnace "Pipe Ore."

912	Crittenden	83.060	.480	trace.	.513	.240	trace.	.248	.135	.104	11.600	4.080	58.168	Hurricane Furnace "Pot Ore."
913	Crittenden	84.640	.580	trace.	.471	.680	.464	.097	.143	.145	10.800	2.920	59.275	Hurricane Furnace "Slate Ore."
914	Crittenden	25.940	.540	trace.	.654	.180	trace.	.132	.169	trace.	3.400	68.160	18.166	Hurricane Furnace "Sand Ore."
931	Edmonson	37.240	2.057	1.180	.419	.680	2.423	.544	.201	.066	9.670	45.670	26.039	Nolin Furnace (Fossil Nautilus.)
932	Estill	60.800	3.060	trace.	.642	2.360	.600	.107	.413	.165	10.540	21.360	42.635	Cottage Furnace (Block Ore.)
933	Estill	66.140	1.460	trace.	.803	1.140	.310	.213	.405	.053	7.560	22.360	46.303	Cottage Furnace (Speckled Ore.)
934	Estill	52.454	.660	trace.	.852	2.480	.740	.107	.366	.167	8.900	33.980	36.755	Cottage Furnace (Rough Ore)
935	Estill	45.540	3.496	trace.	1.028	.980	.925	.145	.434	.190	8.700	39.080	31.891	Cottage Furnace (Kidney Ore.)
936	Estill	62.200	.440	trace.	2.742	1.620	.502	.135	.508	.192	10.760	21.080	43.559	Cottage Fur. (Buzzard Bank Ore.)
944	Estill	71.600	.520	.680	1.408	1.680	.822	.303	.492	.202	11.280	11.120	50.042	Old Furnace ore banks.
945	Estill	62.480	3.349	trace.	.513	.920	.591	.372	.714	.143	10.800	20.580	43.756	Old Furnace ore banks.
993	Greenup	46.640	2.440	.380	1.902	1.380	.412	.255	.656	.192	9.300	36.240	32.662	Kenton Fur. (Blue. Lim. Ore.)
996	Greenup	33.540	4.887	trace.	1.635	.280	.733	.290	.502	.265	8.860	49.480	23.480	Kenton Furnace (Block Ore.)
997	Greenup	78.840	.980	trace.	.471	2.264	.541	.166	.127	.319	11.960	3.980	55.213	Kenton F. (ore with S. C. Lim'st.)
998	Greenup	82.240	.580	trace.	1.041	5.984	.310	.269	.224	.093	7.340	1.920	57.595	Kenton Fur. (John Conley Ore.)
999	Greenup	44.980	2.580	trace.	.894	.080	.694	.372	.135	.260	8.400	41.680	31.500	Ken. Fur. (Rough Big Block Ore.)
1000	Greenup	51.400	3.720	trace.	1.343	.880	2.462	.386	.440	trace.	10.600	28.520	35.996	Kenton Fur. (Little Block Ore.)
1001	Greenup	49.740	3.000	trace.	.603	.480	1.742	.269	.166	.179	8.600	35.160	26.594	Kenton Furnace (Marl Ore)
1002	Greenup	59.680	5.120	trace.	.763	1.080	2.037	.303	.251	.264	7.160	23.560	33.000	Kenton Fur. (Flat Kidney Ore.)
1003	Greenup	21.740	19.160	trace.	.628	.080	trace.	.990	.165	.119	10.300	47.480	15.225	Kenton Fur. (near Pink Clay Ore.)
1004	Greenup	83.880	.280	trace.	.543	5.380	.822	.236	.252	trace.	7.760	1.680	58.742	Kenton Furnace (Dogstone Ore)
1005	Greenup	46.540	3.148	trace.	.919	1.080	1.232	.303	.618	.015	9.340	37.320	39.396	Kenton Furnace (Fossiliferous.)
1017	Greenup	74.740	.980	trace.	1.180*	1.629*	.758	.544	.242	.144	12.828	6.964	52.342	Bellefonte Fur. (Rejected Ore.)
1019	Greenup	43.280	1.580	33.180	2.337*	1.180	.508	.338	.374	.120	3.919	13.184	30.309	Raccoon Fur. exterior of Co. ore.
1020	Greenup	45.070	.730	trace.	.808	.355	1.056	.165	.337	.114	7.800	44.720	31.563	Rac. Fur. Ferrug's Conglomerate.
1022	Greenup	61.640	1.200	14.380	1.818	.380	1.591	.067	.324	.205	7.640	10.800	43.167	Pennsylvania Fur. (New Bank).
1023	Hancock	33.640	2.980	.580	10.603*	.784	.374	.612	.424	.249	5.484	44.180	23.658	Ferruginous Conglomerate.
1092	Livingston	78.310	.780	trace.	.850	.684	.630	.166	.154	.242	11.800	6.480	54.840	Ozeoro Furnace (Brown Ore.)
1093	Livingston	76.340	.180	trace.	.850	.884	.438	trace.	.126	trace.	11.900	8.760	53.462	Ozeoro Furnace (Pot Ore.)
1102	Lyon	78.080	.480	trace.	.407	1.084	.758	.097	.424	.120	10.820	9.480	54.622	Mammoth Fur. (Brown Ore, A.)
1103	Lyon	74.547	1.080	trace.	.479	.980	1.399	.132	.251	.207	11.100	10.680	52.206	Mammoth Fur. Brown Ore, B.
1104	Lyon	76.425	.440	trace.	.441	.380	.615	.132	.143	.145	11.100	10.980	53.522	Mammoth Fur. (Brown Ore, C.)
1105	Lyon	64.433	1.880	trace.	.446	.180	.807	.200	.135	.016	9.700	23.920	45.123	Mammoth Fur. (Brown Ore, D.)
1106	Lyon	72.356	.480	trace.	.443	.480	.502	.097	.328	.255	11.300	13.480	51.022	Mammoth Fur. (Brown Ore, E.)
1107	Lyon	64.269	.580	trace.	.479	.680	.871	.180	.251	.002	10.500	21.880	44.939	Mam. Fur. (Honey-comb Ore.)
1108	Lyon	76.880	1.130	trace.	.795	1.080	.867	.098	.502	.109	11.700	6.680	53.840	Mam. Fur. (Brown Ore, No. 11.)
1115	Lyon	85.637	.580	trace.	.690	1.280	1.143	.306	.463	.195	5.900	4.480	59.973	Suwannee Fur. (Iron Mount. Ore.)
1162	Muhlenburg	67.340	1.000	trace.	.615	.240	1.591	.680	.154	.106	11.300	16.980	47.159	Hoskins' Ore, l'r bed, Muddy riv.
1226	Trigg	86.540	.580	trace.	.989	.184	.374	.166	.193	.076	5.560	7.080	60.605	Empire Furnace "Pot Ore."
1227	Trigg	68.540	.430	trace.	.854	.384	.156	.122	.502	.129	11.180	17.100	48.009	Empire Furnace "Brown Ore."
1233	Trigg	78.840	1.380	trace.	.873	.980	.483	.441	.270	.197	3.720	11.580	47.230	Centre Furnace "Pot Ore."
1234	Trigg	73.54	1.380	trace.	.500	.640	.290	.097	.359	.123	11.320	9.740	51.511	Centre Furnace "Brown Ore."

(TABLE III. (A.) IRON ORES. *Limonites*—Continued.)

Number in the report.	County.	Oxide of iron.	Alumina.	Carbonate of lime.	Magnesia.	Brown oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Combined water.	Silica, &c.	Percentage of iron.	Remarks.
1235	Trigg------	73.340	0.921	trace.	0.527	0.440	0.159	0.475	0.289	0.043	9.460	15.380	51.361	Centre Fur. Brown Ore near fur.
1244	Trigg------	77.070	.480	trace.	.773	.580	.438	·097	.308	.270	11.100	9.480	53.973	Fulton Furnace "Pot Ore."
1245	Trigg------	73.680	.380	trace.	.649	.380	.886	.097	.231	.021	10.800	13.230	51.599	Fulton Furnace "Brown Ore."
1252	Union -----	38.240	.778	0.580	.615	.580	.502	4.426	.328	.201	5.100	11.300	--------	Bitumen, &c., = 37.800; Curlew Black Band.

* Carbonates.

TABLE III. (B.) IRON ORES. (*Carbonate of Iron.*)

Number in the report.	County.	Specific gravity.	Carbonate of iron.	Oxide of iron.	Alumina.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Bituminous matter.	Silex and silicates.	Water.	Percentage of iron.	Remarks.
787	Bath	3.330	47.330	11.880	4.180	5.480	7.754	1.987	0.886	0.475	0.674	0.071	......	19.580	......	31.192	Clear Creek Furnace.
788	Bath	....	44.575	7.121	3.520	5.280	7.187	.722	1.120	.338	.783	.347	......	27.340	......	26.630	Clear Creek Furnace.
789	Bath	....	43.716	3.937	1.881	1.184	5.903	.873	.490	.303	.355	.286	......	40.880	......	23.838	Clear Creek Furnace.
865	Carter	....	20.190	51.310	.380	.880	2.926	1.475	.822	.441	.374	.010	......	11.780	9.412	45.688	Star Furnace.
866	Carter	....	87.527	.778	.984	trace.	1.924	1.324	.207	.613	.181	trace.	......	6.680	......	42.807	Star Furnace.
867	Carter	....	60.134	4.775	.480	1.080	5.105	1.987	.540	.819	.193	.159	......	21.440	......	32.396	Star Furnace.
886	Crittenden ...	3.353	64.191	2.948	.480	2.124	13.203	1.324	.822	.201	.704	.200	......	12.980	......	32.943	Crittenden Furnace.
937	Estill	3.576	78.066	1.050	2.460	1.290	4.508	3.492	.438	.176	.231	.198	......	8.770	......	38.461	Cottage Furnace.
939	Estill	....	54.147	16.197	1.160	6.190	3.865	2.680	.438	.303	.250	.321	......	13.120	......	37.495	Cottage Furnace.
948	Estill	....	64.210	4.543	.580	1.920	9.335	2.077	.464	.200	.424	.281	......	13.180	2.793	34.203	Station Camp creek.
994	Greenup	2.985	41.260	4.760	1.580	1.880	5.981	2.960	.374	.290	.579	.150	......	0.080	......	22.788	Kenton Furnace.
995	Greenup	3.275	56.267	3.882	5.980	4.980	3.026	.873	2.029	.750	.347	.186	......	20.640	......	29.024	Kenton Furnace.
1012	Greenup	....	50.936	....	2.200	1.980	4.365	1.445	.482	.612	not es	not es	......	37.980	......	24.609	Little Sandy river.
1014	Greenup	3.446	67.624	5.088	.780	17.690	4.933	1.650	1.053	.090	.380	.202	......	.520	......	36.234	Caroline Furnace.
1016	Greenup	....	81.448	1.403	.240	2.580	2.581	1.926	.374	1. 97	.366	.011	......	7.924	......	0.646	Bellefonte Furnace.
1018	Greenup	3.178	17.703	21.286	.680	37.580	2.901	1.475	.310	1.470	.270	.166	......	8.440	7.659	23.488	Racoon Furnace.
1024	Hancock	3 548	73.626	5.752	1.460	1.380	7.020	.584	.694	.248	.201	.172	......	9.0 0	......	30.596	Lewisport.
1052	Laurel	....	72.900	....	1.980	3.180	4.739	1.264	1. 87	.454	not es	not es	......	13.520	......	35.284	On Gillis' branch.
1152	Montgomery ..	....	46.171	18.489	2.160	6.950	4.936	1.626	.630	.047	.366	.170	......	17.480	......	35.254	Wills' (Clinton group.)
1155	Morgan	....	48.620	16.650	1.920	1.480	6.360	.722	.505	.517	.598	......	......	17.550	5.078	36.472	In coal shale.
1158	Morgan	....	55.382	2.234	.380	1.684	2.274	1.776	.335	.289	.232	.177	3.377	31.880	......	28.521	On Red river.
1210	Owsley	3.271	38.321	22.554	.680	.153	8.414	1.023	.759	.372	.309	.200	4.620	22.580	......	34.304	In the coal shales.
1211	Owsley	3.405	62.292	7.796	.520	1.984	8.885	1.324	1.463	.510	.292	.347	2.687	11.9 0	......	5.400	On J. G. McGuire's land.
1022	Powell	3..57	51.082	10.500	2.480	5.780	10.048	4.034	1.048	.235	.527	.267	......	14.040	......	32.021	Knob iron ores.
1218	Pulaski	....	79.781	1 561	1.060	1.580	3.004	.120	.738	.269	.212	.034	.820	8.7.0	......	30.638	Cumberland Coal Co. mines.

TABLE IV. COALS.

Number in the report.	County.	Specific gravity.	Moisture.	Volatile combustible matters.	Carbon in the coke.	Ashes.	Total volatile matters.	Coke.	Sulphur.	Crude oil from 1000 grains.	Remarks.
819	Bath	1.288	2.90	37.30	56.50	3.30	40.20	59.80	0.806		Flower hill bank, on Indian creek.
820	Bath	1.288	5.30	35.84	55.80	3.06	41.14	58.86	0.672		Cox and McCormick's, on Beaver creek.
821	Bath	1.268	2.30	40.10	53.86	3.74	42.40	57.60	2.522		"Big Bank," on Indian creek.
834	Breathitt	1.278	0.70	44.00	39.90	15.40	44.70	55.30	0.452	273 grains.	Cannel coal, Quicksand creek.
835	Breathitt	1.219	0.30	56.70	38.10	4.90	57.00	43.00	1.513	364 grains.	Cannel coal, from South's bank.
870	Carter	1.266	7.70	36.50	53.80	2.00	44.20	55.80	1.267		Star Furnace.
871	Carter	1.200	.60	66.30	28.30	4.80	66.90	33.10	1.320	436 grains.	Cannel coal, Stinson bank.
872	Carter		1.26	39.64	49.40	9.70	40.90	59.10	0.694		Carter's hill, (upper 18 inches.)
873	Carter	1.298	4.40	35.00	52.70	7.90	39.40	60.60	3.261		Carter's hill, (under 18 inches.)
874	Carter	1.299	4.26	35.94	53.30	6.50	40.20	59.80	2.339		Tar Kiln branch of Stinson's cr'k, (upper part) (bituminous.)
875	Carter	1.145	0.90	64.16	27.04	7.90	65.06	34.94	2.843	411 grains.	Tar Kiln branch of Stinson's cr'k, (under part) (cannel.)
929	Crittenden	1.297	1.00	36.50	51.90	10.60	37.50	62.50	0.686		Sneed's mines, (cannel coal portion.)
964	Estill	1.336	2.90	37.76	50.84	8.50	40.66	59.34	4.350		Billy's Fork of Miller's creek, (Townsend's.)
1021	Greenup	1.271	4.70	40.20	52.40	2.70	44.90	55.10	0.837	209 grains.	Bradford's ——— on Fulton Forge farm.
1035	Hancock	1.359	4.30	37.20	42.60	15.90	41.50	58.50	1.306		Upper part of Mayo's coal, Hawesville.
1036	Hancock	1.268	5.46	41.14	48.80	4.60	46.60	53.40	3.661		Boyd's coal, Hawesville.
1057	Hopkins	1.274	4.06	37.44	54.80	3.70	41.50	58.50	2.796		Arnold's coal.
1064	Jackson	1.290	1.10	38.20	50.80	9.90	39.30	60.70	0.962		Mr. Isaac's coal.
1153	Montgomery	1.264	2.70	38.60	55.80	2.90	41.30	58.70	1.072		30 feet under the conglomerate.
1054	Montgomery	1.270	3.60	38.00	55.40	3.00	41.60	58.40	1.210		"Cabin bank," Hawkins' branch of Slate creek.
1160	Morgan	1.253	4.40	34.80	60.06	0.74	39.20	60.80	0.672		"Casby's bank," Elk Fork of Elk branch.
1161	Morgan	1.250	3.34	41.26	54.06	1.34	44.60	55.40	0.870		On big branch of Lick Fork of Elk branch.
1163	Muhlenburg	1.287	3.30	37.80	56.10	2.80	41.10	58.90	2.711		McNairy's, seven feet coal.
1164	Muhlenburg	1.593	7.06	30.84	58.70	3.40	37.90	62.10	0.879		Upper coal at Airdrie.
1199	Ohio	1.298	2.60	41.20	52.66	3.54	43.80	66.20	1.829		Bull Run coal.
1200	Ohio	1.389	1.50	39.70	37.80	21.00	41.20	58.80	3.234		Crawford's coal.
1213	Owsley	1.275	2.06	34.34	56.50	7.10	36.40	63.60	0.796		Big Vein, (Philips'.)
1214	Owsley	1.235	2.30	37.30	58.90	1.50	39.60	60.40	.645		Big Vein, (McGuire's.)
1031	Owsley	1.338	1.50	36.70	55.14	6.60	38.26	61.75	4.074		Big Vein, Beatty's river bank.
1219	Rockcastle	1.419	1.66	37.74	58.26	2.34	39.40	60.60	.808		Wm. Dyre's bank, Skeggs' creek.

TABLE IV. COALS—Continued.

Number in the report.	County.	Specific gravity.	Moisture.	Volatile combustible matters.	Carbon in the coke.	Ashes.	Total volatile matters.	Coke.	Sulphur.	Crude oil from 1000 grains.	Remarks.
1220	Rockcastle	1.259	1.70	36.30	59.80	2.20	38.00	62.00	0.685	----------	Henry Mullins' bank, Skeggs' creek.
1254	Union	1.623	2.00	35.40	37.30	25.30	37.40	62.60	16.142	----------	Payne & Berry's coal, (upper part.)
1255	Union	1.274	4.50	37.10	55.10	3.30	41.60	58.40	3.262	----------	Payne & Berry's coal, (lower part.)
1256	Union	1.282	0.40	35.50	48.20	15.90	35.90	64.10	1.017	----------	Casey's mines, (cannel, upper part.)
1257	Union	1.328	1.00	40.30	44.30	14.40	41.30	58.70	9.639	190 grains.	Curlew mines, (bird's-eye coal.)
1258	Union	1.295	1.34	35.96	59.10	3.60	37.30	62.70	1.609	----------	Mulford Coal Company bank.

TABLE V. SANDSTONES, SHALES, CLAYS, &c.

Number in the report.	County.	Sand and silicates.	Carbonate of lime.	Magnesia.	Alumina.	Oxide of iron.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at a red heat.	Bituminous matters.	Lime.	Remarks.
824	Bracken	88.580	0.920	0.899		6.460		0.438	0.200	0.560	0.166	1.900	------	------	Lower Silurian mudstone.
836	Breckinr'ge	98.340	trace.	.266		.580		trace.	.042	trace.	trace.	.772	------	------	White sandstone.
847	Bullitt	90.380	trace.	.800		5.660		.118	.231	.463	.142	2.206	------	------	Knob building stone.
855	Bullitt	69.420	------	------		12.725		.246	3.830	1.271	.217	12.040		1.458	Black (Devonian) shale.
899	Crittenden	99.080	trace.	.360		.080		trace.	.063	.386	.121	.300	------	------	Crittenden Furnace (hearthstone.)
900	Crittenden	98.680	trace.	.400		.380		trace.	trace.	.464	.058	.500	------	------	Crittenden Furnace (hearthstone.)
916	Crittenden	97.400	trace.	.566		.980		trace.	trace.	.213	.156	.685	------	------	Hurricane Furnace (hearthstone.)
917	Crittenden	98.580	trace.	.666		.640		trace.	trace.	.231	.124	.240	------	------	Hurricane Furnace (hearthstone.)
918	Crittenden	98.640	trace.	.266		.580		trace.	trace.	.212	.028	.400	------	------	Hurricane Furnace (hearthstone.)
927	Crittenden	62.280	*.325	1.815	18.880	3.560	------	.115	------	3.358	trace.	9.667	------	------	Hurricane Furnace (fire clay.)
928	Crittenden	96.980	trace.	.599		.680		not est.	.058	.162	.129	1.392	------	------	Hur. Furnace (silicious concretion.)
946	Estill	71.780	none.	.547	17.580	2.420	------	not est.	.112	2.271	.322	4.400	------	------	Potters' clay.
959	Estill	82.280	.244	.433		6.860		.310	.132	1.101	.340	8.300		------	Black Devonian shale.
991	Grant	78.480	2.780	1.401		12.340		.630	.338	.957	trace.	3.074	------	------	Shale (Lower Silurian.)
1006	Greenup	44.020	trace.	.373	32.81	7.88	------	.310	------	.146	1.121	13.360	------	------	Kenton Furnace. } Ferruginous clay-stones.
1007	Greenup	42.920	trace.	.245	37.44	4.94	------	.207	------	.135	.205	13.700	------	------	Kenton Furnace. } Ferruginous clay-stones.
1008	Greenup	43.780	trace.	.281		41.000		.246	------	.193	.856	13.360	------	------	Kenton Furnace. } Ferruginous clay-stones.
1049	Henry	80.380	.780	.933		11.650		.310	.304	.490	.257	4.896	------	------	Mastodon bed clay.
1050	Henry	46.480	trace.	.566		40.172		3.128	.463	.463	.141	8.746	------	------	Ditto (ferruginous.)
1066	Lewis	90.920	trace.	.732		5.800		.118	.300	trace.	trace.	2.100	------	------	Soft yellow sandstone.
1095	Livingston	93.280	trace.	.513		3.360		trace.	.132	.193	.050	2.100	------	------	Hearthstone Ozeora Furnace.
1117	Lyon	98.080	trace.	.466		.440		trace.	.066	.328	.255	.600	------	------	Do. Suwannee Furnace, Union co.
1122	Madison	62.580	trace.	1.276	21.980	4.78	trace.	not est.	.234	2.607	.500	6.140	------	------	Potters' clay.
1124	Madison	63.120	11.180	2.034		8.560		.143	1.653	1.363	------	12.000		------	Black shale.

TABLE V. SANDSTONES, SHALES, CLAYS, &c.—Continued.

Number in the report.	County.	Sand and silicates.	Carbonate of lime.	Magnesia.	Alumina.	Oxide of iron.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at a red heat.	Bituminous matters.	Lime.	Remarks.
1221	Rowan	90.240	1.480	0.928		3.965		0.117	0.269	0.336	0.089	2.900	------	------	Sandstone. Knob building stone.
1224	Scott	75.920	1.480	†6.290		11.660		.489	.338	not est.	not est.	3.900	------	------	Shale, milk-sickness district.
1225	Scott	77.840	3.784	†3.401		9.140		.566	.303	.579	.047	4.340	------	------	Mudstone, milk-sickness district.
1253	Union	94.080	trace.	.733		2.660		.092	.097	.250	.103	1.700	------	------	Hearth sandstone, Emp. Furnace.

* Lime. † Carbonate.

TABLE VI. IRON FURNACE SLAGS.

Number in the report.	County.	Silica.	Alumina.	Lime.	Magnesia.	Protoxide of iron.	Protoxide of manganese.	Phosphoric acid.	Sulphuric acid or sulphur.	Potash.	Soda.	Oxygen in the bases.	Oxygen in the silica.	Proportion of the oxygen in the bases to the oxygen in the silica.	Furnace.
905	Crittenden	59.580	7.980	23.164	1.358	4.464	0.260	not est.	Sulphur. 0.135	1.425	0.130	12.258	30.050	as 1 : 2.451	Crittenden fur.
906	Crittenden	61.980	9.080	24.623	1.538	.963	.446	not est.	.052	1.317	.275	12.495	32.182	as 1 : 2.575	Crittenden fur.
907	Crittenden	64.880	7.480	15.847	1.287	7.164	.781	not est.	.080	2.047	.271	10.692	33.688	as 1 : 3.150	Crittenden fur.
908	Crittenden	65.520	8.280	22.155	1.645	1.584	.353	not est.	.149	1.892	.162	11.599	34.021	as 1 : 2.941	Crittenden fur.
923	Crittenden	55.360	14.440	25.578	3.304	1.494	trace.	not est.	not est.	1.815	.173	16.017	28.755	as 1 : 1.798	Hurricane fur.
924	Crittenden	55.560	13.380	25.241	3.660	1.854	trace.	not est.	not est.	1.495	.199	15.611	28.859	as 1 : 1.848	Hurricane fur.
925	Crittenden	56.980	13.280	16.936	2.845	10.495	trace.	not est.	not est.	1.398	.016	14.729	29.585	as 1 : 2.008	Hurricane fur.
926	Crittenden	59.980	11.880	21.066	3.566	4.014	trace.	not est.	not est.	1.151	.388	14.154	31.143	as 1 : 2.200	Hurricane fur.
940	Estill	56.300	16.100	21.414	1.845	1.170	.595	0.654	not est.	1.757	.190	15.070	29.232	as 1 : 1.930	Cottage fur.
941	Estill	58.040	12.360	18.058	1.333	6.122	1.060	.117	not est.	1.970	.309	12.496	30.136	as 1 : 2.331	Cottage fur.
1015	Greenup	52.580	11.280	16.905	2.141	10.783	2.121	trace.	not est.	3.121	.265	14.397	27.301	as 1 : 1.896	Clinton furnace
1099	Livingston	62.580	7.380	25.465	1.244	.842	.539	trace.	not est.	1.313	.905	11.959	32.493	as 1 : 2.717	Ozeoro furnace.
1100	Livingston	63.380	8.960	20.751	1.462	3.456	.450	trace.	not est.	1.649	.207	11.881	32.909	as 1 : 2.790	Ozeoro furnace.
1101	Livingston	63.380	9.560	19.461	2.543	2.914	.487	trace.	not est.	1.680	.202	12.074	32.909	as 1 : 2.725	Ozeoro furnace.
1112	Lyon	64.880	3.980	22.772	1.358	3.258	.446	not est.	.289	1.854	.375	10.106	33.687	as 1 : 3.332	Mammoth fur.
1113	Lyon	65.080	8.040	20.190	.877	4.158	.541	not est.	.290	1.398	.365	11.217	33.791	as 1 : 3.012	Mammoth fur.
1114	Lyon	60.280	5.800	13.288	.948	16.525	.651	not est.	.324	1.676	.397	11.065	31.299	as 1 : 2.828	Mammoth fur.
1118	Lyon	61.180	5.380	23.333	1.071	4.410	.818	not est.	.269	1.661	.176	11.088	31.766	as 1 : 2.866	Suwannee fur.
1229	Trigg	64.480	5.280	19.317	1.304	6.462	.911	not est.	not est.	1.953	.319	10.514	33.485	as 1 : 3.204	Empire furnace.
1237	Trigg	65.140	7.580	22.715	.826	1.404	.171	not est.	not est.	1.564	.228	11.305	33.822	as 1 : 2.991	Centre furnace.
1238	Trigg	63.680	8.880	21.088	.965	2.505	.632	not est.	not est.	1.630	.180	11.566	33.064	as 1 : 2.859	Centre furnace.
1248	Trigg	64.880	8.980	21.200	1.087	2.660	.540	not est.	not est.	1.533	.358	11.722	33.687	as 1 : 2.874	Fulton furnace.

TABLE VII. PIG IRON.

Number in the report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Total carbon.	Manganese.	Silicon.	Slag.	Aluminum.	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Furnace, &c.
781	Bath	7.069	94.542	1.700	none.	1.700	0.692	1.067	0.080	0.309	trace.	0.169	0.142	0.050	0.084	0.135	Slate F.
795	Bath	6.912	97.060	.400	none.	.400	.634	.471	none.	.255	trace.	.220	.177	.140	.108	.166	Clear cr. F. Sal.
869	Carter	7.093	90.606	2.100	1.520	3.620	1.507	2.181	.284	.301	trace.	.303	.073	trace.	1.404	.135	Star Furnace-
901	Crittenden	6.983	90.733	1.884	1.716	3.600	.129	3.490	.664	.084	trace.	.271	.102	.065	.864	.127	Crittenden F.
902	Crittenden	6.990	91.094	2.024	.340	2.364	.633	3.777	.724	.202	trace.	.414	.080	.097	.443	.052	Crittenden F.
903	Crittenden	6.603	91.111	2.224	.420	2.642	.417	3.508	.984	.202	trace.	.417	.054	.077	.320	.052	Crittenden F.
904	Crittenden	7.399	93.879	.384	4.500	4.884	.344	.623	.084	.202	trace.	.451	.080	.097	.451	.127	Crittenden F.
919	Crittenden	7.065	91.871	2.040	2.284	4.324	.172	2.180	.184	.202	trace.	.368	.064	.054	.727	.066	Hurricane F.
20	Crittenden	7.106	92.143	2.624	1.560	4.184	.433	2.065	.284	.170	trace.	.348	.048	.082	.540	.066	Hurricane F.
21	Crittenden	7.926	92.263	.984	5.360	6.344	.417	.142	.184	.202	trace.	.328	.105	.177	.464	.108	Hurricane F.
922	Crittenden	7.278	92.336	2.224	2.860	5.084	.345	.624	.084	.149	trace.	.220	.089	.012	.446	not est.	Hurricane F.
942	Estill	7.112	93.689	3.150	.610	3.760	.689	.989	.320	.047	trace.	.258	.068	.098	.344	.060	Cottage F.
943	Estill	7.121	93.793	3.220	.550	3.770	.548	.793	.260	.055	trace.	.235	not est.	not est.	.474	.120	Cottage F.
010	Greenup	6.861	94.162	2.120	.180	2.300	.078	1 085	.284	.255	trace.	.675	.112	.049	1.050	.232	Kenton F.
1011	Greenup	------	94.057	1.556	.914	2.470	.345	.507	.284	.149	trace.	.179	.640	.109	.823	.259	Kenton F.
1096	Livingston	7.029	91.714	2.624	1.700	4.324	.634	1.796	.244	.063	trace.	.263	.089	.012	.755	.053	Ozeoro F.
1097	Livingston	7.082	92.548	2.524	1.380	3.904	.417	1.853	.384	.095	trace.	.222	.092	trace.	.671	.061	Ozeoro F.
1098	Livingston	7.295	93.459	1.984	2.360	4.344	.201	.892	.184	.202	trace.	.165	.096	.006	.502	.071	Ozeoro F.
1109	Lyon	6.853	93.086	2.660	1.140	3.800	.421	1.681	.384	.255	trace.	.282	.064	.070	.781	.080	Mammoth F.
1110	Lyon	7.038	92.464	2.800	1.500	4.300	.233	1.104	.384	.201	trace.	.189	.080	.145	1.065	.080	Mammoth F.
1111	Lyon	7.410	93.251	none.	4.500	4.500	.276	.094	.484	.095	trace.	.228	.134	.135	1.346	.080	Mammoth F.
1119	Lyon	6.989	92.414	2.644	2.456	5.100	.201	1.950	.384	.224	trace.	.258	.096	.102	.192	.100	Suwannee F.
1120	Lyon	6.924	92.560	2.824	1.876	4.700	.273	.863	.484	.131	trace.	.419	.086	.014	.321	.149	Suwannee F.
1121	Lyon	7.607	94.338	.984*	3.000	3.984	.129	.375	none.	.095	trace.	.325	.102	.057	.387	.152	Suwannee F.
1230	Trigg	7.063	92.984	2.700	2.060	4.760	.132	1.104	.284	.177	trace.	.226	.052	trace.	.249	.094	Empire F.
1231	Trigg	7.487	93.686	3.200	1.360	4.560	.133	1.536	.136	.307	trace.	.264	.104	trace.	.389	.226	Empire F.
1232	Trigg	7.609	95.747	trace.	2.400	2.400	.334	.373	.104	.149	trace.	.224	.157	trace.	.333	.080	Empire F.
1239	Trigg	7.126	94.786	2.500	1.700	4.200	.133	1.345	.184	.177	trace.	.285	.048	.042	.080	.122	Centre F.
1240	Trigg	7.411	96.212	2.000	1.000	3.000	.133	.624	.184	.177	trace.	.333	.070	.065	.108	.152	Centre F.
1249	Trigg	7.144	93.546	3.360	1.640	5.000	.276	1.008	.184	.069	trace.	.264	.064	.070	.192	trace.	Fulton F.
1250	Trigg	6.918	93.204	2.500	1.800	4.300	.276	1.008	.884	.095	trace.	.311	.064	.070	.252	.053	Fulton F.

* A brown carbonaceous material, not true graphite.

APPENDIX.

For the sake of comparison with the soils of Kentucky, a number of soils from the States of Illinois, Indiana, Iowa, Minnesota, and Wisconsin, mostly prairie soils, collected by Dr. D. D. Owen, during his northwestern explorations, were submitted to analysis. The results are given below.

No. 1262—SOIL. *Labeled "Illinois Virgin Prairie Soil. Surface soil, at the junction of the Illinois Central, and the Ohio and Mississippi railroads, Odin, Marion county, Illinois. (Collected by W. A. Gunn, Esq.")*

The dried soil is of a mouse color.

No. 1263—SOIL. *Labeled "Upland Soil, (sec. 16, T. 27, N. R. 15 W. of 4th P. M.) L'Eau Gallee, Wisconsin. On the confines of the lower sandstone and lower magnesian limestone, of the Lower Silurian formation." (Collected by Dr. Owen.)*

Dried soil of a mouse color, containing a large proportion of vegetable remains, and some small rounded clear grains of sand.

No. 1264—SOIL. *Labeled "Soil from the White Earth Prairie: six miles above Traverse des Sioux. Minnesota or St. Peters river." (Collected by Dr. D. D. Owen.)*

Dried soil of a dark umber color, nearly black; exhibiting much silicious sand, in the form of rounded transparent and reddish and milky grains. A fragment of dark-brown oxide of iron sifted out of it.

No. 1265—SOIL. *Labeled "Virgin Soil, collected near the cliffs of the sub-carboniferous magnesian limestone; three or four miles below the falls of the Iowa river, Iowa." (Collected by Dr. D. D. Owen.)*

Dried soil of a dark mouse color, containing small rounded grains of hyaline and milky quartz sand; and an irregular fragment of yellowish magnesian limestone.

No. 1266—SOIL. *Labeled "Upland Soil, in the woods near Ballard's Coal Bank, Iowa river."* (*Collected by Dr. Owen.*)

Dried soil of a dark slate-grey color.

No. 1267—SOIL. *Labeled "Soil near the plaster bed, near correction line. Upper Des Moines river, below Lizard Fork, Iowa."* (*Collected by Dr. D. D. Owen.*)

Dried soil of an umber grey or light umber color; contains small rounded grains of clear and reddish quartz sand, and some small rounded quartz pebbles and shot iron ore.

No. 1268—SOIL. *Labeled "Soil on the sub-carboniferous limestone on the Iowa river,* (*section* 1, *Township* 82, *Range* 15,) *below Toledo, Iowa."* (Collected by Dr. D. D. Owen.)

Dried soil of a dark mouse color; it contains small rounded grains of clear quartz sand.

One thousand grains of each of these soils, air-dried, were digested, severally, for a month, in water charged with carbonic acid. The soluble materials extracted are stated in the following table, viz:

	No. 1262. Illinois.	No. 1263. Wis'n.	No. 1264. Minn'a.	No. 1265. Iowa.	No. 1266. Iowa.	No. 1267. Iowa.	No. 1268. Iowa.
Organic and volatile matters	0.633	8.523	4.100	3.000	1.060	0.444	2.433
Alumina, and oxides of iron and manganese and phosphates	.097	1.187	2.030	1.203	.830	.213	.896
Carbonate of lime	.497	6.430	3.847	10.053	5.707	.863	2.173
Magnesia	.101	.050	.610	.443	.393	.199	.405
Sulphuric acid	.045	.067	.033	.039	.033	.050	.039
Potash	.035	.240	.201	.061	.154	.091	.064
Soda	.057	.129	.532	.051	.055	.057	.114
Silica	.264	.564	.414	1.347	.464	.447	.264
Loss	.021	-------	.016	.220	.921	.079	-------
Soluble extract, dried at 212° F., (grains)	1.750	17.190	11.783	16.417	9.617	2.443	2.388

The large amount of soluble matter in most of these soils is remarkable. It will also be observed that most of them give up a greater quantity of *silica* in its soluble condition than any of the Kentucky soils; which is no doubt due to the very large amount of the decomposed remains of grasses which they contain; most of these soils, except the one from "near Ballard's, in the woods," being prairie soils, on which for

an unknown time the grasses have annually grown up and decayed; leaving in their remains not only a large amount of soluble matter in general but also a large proportion of soluble silica.

The composition of these seven soils, dried at 400° F., is as follows:

	No. 1162. Illinois.	No. 1263. Wisconsin.	No. 1264. Minnesota.	No. 1265. Iowa.	No. 1266. Iowa.	No. 1267. Iowa.	No. 1268. Iowa.
Organic & volatile matters	5.082	19.201	10.949	14.905	5.530	2.606	7.150
Alumina	3.200	1.150	3.675	1.565	1.560	2.285	6.035
Oxide of iron	2.410	1.860	5.160	2.785	2.420	2.110	4.310
Carbonate of lime	.295	1.945	.945	38.395	1.370	.445	.871
Magnesia	.398	.815	.701	1.782	.580	.561	.891
Brown oxide of manganese	.145	.395	.295	.195	.120	.071	.290
Phosphoric acid	.152	.218	.275	.229	.118	.062	.164
Sulphuric acid	.072	.175	.110	.119	.059	.058	.067
Potash	.222	.270	.406	.191	.290	.323	.463
Soda	.039	.092	.177	.057	.038	.063	.075
Sand and insoluble silicates	87.895	74.045	78.045	40.620	87.845	91.595	79.280
Loss	.090	-------	-------	-------	.070	-------	.404
Total	100.000	100.166	100.738	100.843	100.000	100.179	100.000
Moisture, expelled at 400° F.	2.40	6.125	4.475	3.725	1.900	1.200	4.525

These soils may be considered amongst the most fertile of the northwest; in the virgin or uncultivated condition. They are generally remarkable for the large proportion of *organic materials* which they contain, and consequently for their great amount of *soluble matter*. Mostly the proportions of alumina and oxide of iron are moderate, even below the average; whilst in the mineral elements which enter into the composition of vegetables and animals* they are generally rich; but they do not in this respect excel, and several do not equal, the rich lands of Kentucky based on the soft beds of the blue limestone of the Lower Silurian formation. Soil No. 1265, from near the cliffs of the sub-carboniferous limestone, &c., Iowa, contains an extraordinary quantity of carbonate of lime.

CHEMICAL INVESTIGATION INTO THE COMPOSITION OF THE ASHES OF KENTUCKY TOBACCO.

In view of the importance of the tobacco crop in Kentucky, and of the rapidity with which this plant exhausts the soil on which it is grown, it was thought advisable to endeavor, by the analysis of the ashes of a variety of samples from different parts of the country, as well as by

* Viz: Potash, soda, lime, magnesia, phosphoric and sulphuric acids, &c.

the analysis of the virgin soil and that which had been exhausted by this crop, to ascertain the amount and nature of the mineral ingredients necessary to this plant, as compared with wheat, corn, &c., and thus to find out the best means of preserving or restoring the fertility of the land employed in this kind of culture.

By the kindness of Robert W. Scott, Esq., a number of *premium specimens* of the best leaf tobacco of the State was obtained for this purpose, from the rooms of the State Agricultural Society, at Frankfort. I was also indebted to the politeness of Mr. Spratt, of Pickett's tobacco warehouse, Louisville, who sent, at my request, a large number of samples from many counties of the State, amongst which were several premium specimens. To make the comparison as complete as possible, some of the best Cuba and Florida cigar leaf tobacco were obtained from Mr. Meyer, cigar manufacturer of this city, who had imported them; and who also obliged me by classifying the various samples which I had collected.

Out of all the specimens on hand, thirty were select d from regions representing as many different geological formations as possible; a second object in the investigation being to endeavor to verify the statement made by Liebig in his Agricultural Chemistry, on the authority of Pelouze, that the quality of tobacco is affected by the nature and composition of the soil on which it is grown. The statement referred to is as follows: "A most striking proof of the influence of potash upon vegetation has been furnished by the 'administration' in Paris. For many accurate analyses of the ashes of various sorts of tobacco have been executed, by the orders of the 'administration;' and it has been found, as the result of these, that the value of the tobacco stands in a certain relation to the quantity of potash contained in the ashes. By this means a mode was furnished of distinguishing the different soils upon which the tobacco under examination had been cultivated, as well as the class to which it belonged. Another striking fact was also disclosed through these analyses. Certain celebrated kinds of American tobacco were found gradually to yield a smaller quantity of ashes, and their value diminished in the same proportion. For this information I am indebted to M. Pelouze, Professor of the Polytechnic School in Paris."

The most extended examination of the chemical composition of the

ashes of tobacco, of which I can find any account in the books within my reach, were made by M. Barral, and reported to French Academy; a notice of which I find in the *Comptes Rendus des Sceances de l'Acad. des Sc.*, 22d Dec., 1845, p. 1374. M. Barral seems to have examined a number of samples of tobacco, from various soils and different parts of the world. He found the proportion of the ash to vary in the different parts of the plant, as follows:

In the leaves, it amounted to	23. per cent.
In the midribs of the leaves to	22. per cent.
In the stems to	10. per cent.
In the roots to	7. per cent.
In the seeds to	4. per cent.

In this *notice*, I find the following remarks: "The several kinds of tobacco examined, being from soils naturally very different, gave ashes, the composition of which is very various. But in the midst of this variety a fact presents itself, of which the constancy is worthy of remark. M. Liebig has announced this principle; that, in the same plant, according to circumstances, one base may replace an equivalent proportion of another analogous base. This principle has never before been verified by a suite of experiments made on a plant brought from so many different countries. It results from the figures contained in my *memoire* that, (with exception of the roots,) the quantity of *oxygen* contained in the bases of the ashes of the *stalks, midribs,* and *leaves,* of all kinds of tobacco, is, on an average, 13 *per cent.*" M. Barral adds, that the tobacco is the plant which contains the largest quantity of ashes, and the largest amount of *nitrogen,* in its composition, of all plants.

For the benefit of the non-chemical reader, we will state, that a *base* is a substance, which forms salts with acids; for instance, potash, soda, lime, magnesia, oxide of iron, &c., are all *bases;* and as the *saturating* or *combining* power of the bases is always strictly in proportion to the *oxygen* they contain, the comparison of the amount of oxygen in the various bases is an exact mode of comparing their *equivalent proportion,* or *saturating power.*

The present occasion was taken to endeavor to verify this statement of Liebig, in regard to the equivalency of the bases contained in the ashes of tobacco; and it will be seen, that with some exceptional cases, in which, generally, a very large quantity of magnesia and lime or soda were present, and in some others where the tobacco, grown on poor soil, had but a small percentage of ashes, there is a remarkable regularity in

this respect, notwithstanding the considerable variety in percentage of the ashes. The proportion of *oxygen* in the bases does not vary much from 15 per cent. in the air-dried leaves and midribs alone; whilst the *proportion of ash* varies, in the same samples, from a little more than 12 per cent. to more than 22 per cent.! It is probable, that were the irregular quantity excluded, represented by "carbonic acid and loss," in the tables, the approximation would be greater yet. Thus, it would appear, that within certain limits, although one base may be replaced by another analogous base, in the mineral constituents of vegetables; as, for instance, soda for potash, magnesia for lime, and vice versa, yet they tend to replace each other in *definite proportions*, (or equal saturating quantities,) as in ordinary chemical combinations. M. Barral's calculation giving 13 per cent. as the quantity of oxygen contained in the ash, included that of the *stalks* as well as of the *leaves* and *midribs;* ours giving about 15 per cent. in the ashes of the leaves and midribs alone.

Not having been able to see the original memoir of M. Barral, and finding but very few analyses of tobacco ash recorded, in the works to which I have access, I am unable to compare the following analysis with any considerable number of others; if, indeed, many such analyses have been published, which is doubtful: but in the few which are to be found in the journals of science, the proportion of the ash to the air-dried plant is generally over stated, because the *fine sand*, derived from the dust of the soil which has adhered to the viscid leaves, has not been excluded in the analysis; hence the proportion of *silica* has been stated as high as 12 per. cent. in an analysis quoted by Sprengel, and in that by Merz, quoted at the end of the Chemical Report in the 2d Vol. of these Reports on the Geology of Kentucky, it is stated at more than four and a half per cent. In the thirty analyses given below, the average proportion of the silica is about the third of one per cent. only, and it rarely is found to exceed one and a half per cent.

The fresh leaf of the tobacco is always covered with a viscid secretion, which causes dust, &c., to adhere firmly to the surface, sometimes in considerable quantity. In these analyses the *fine sand*, from the dust of the soil adhering to the leaves, was excluded, by digesting the residual *silicious matters* in a dilute alkaline solution, and rejecting all that was not dissolved in that menstruum, which easily takes up the silica which had entered into the composition of the vegetable, and leaves the *sand* undis-

solved. In treating the Cuba tobacco ash in this way, it was interesting to see the sand, thus excluded, of a marked red color, showing that the plant had grown on the celebrated red soil of that island.

In ten analyses of tobacco ashes by Fresenius and Will, published in the *Journal fur Praktische Chemie*, XXXVIII, 31, June, 1846, the proportion of silica given is from 3.59 to 14.16 per cent.! although they attempted to exclude the *sand* by the use of a caustic alkaline solution. Doubtless they boiled it in too strong a solution, and thus dissolved some of the fine sand itself. They do not give the relative weight of the ash to the dried leaf, and their analyses are so much the less valuable in an agricultural sense. The proportions of *potash*, in their different specimens, vary from 23.33 to 6.01 per cent. of the ashes In Table VII (*a*,) which we have appended, giving the proportions of the several ingredients in one hundred parts of the ashes of the thirty samples analyzed for this Report, the quantity of *potash* varies from 35.38 to 20.54 per cent. In only two specimens does the *silica* appear as high as 10.66 and 9.20 per cent.; and in these, which were the first analyzed, the error mentioned above was committed.

Recently, a report of four analyses of the ashes of tobacco *leaves*, and of three of the ashes of the *stalks*, by Dr. Chas. T. Jackson, of Boston, Mass., together with the analyses of four tobacco soils and four sub-soils, have appeared in the Patent Office Report (AGRICULTURE) for 1858, p. 290. The soil and plants were from Massachusetts and Maryland. In these tobacco leaf analyses the quantity of "*silica and silicious dust*" is from 8.60 to 29.40 per cent. of the ashes! No effort having been made to exclude the *silicious sand* from the silica which entered into the composition of the leaf. The proportion of *ashes* to the air-dried leaf, with this great irregularity in the silicious dust included, varies from 14.53 to 20.20 per cent., and the quantity of *potash*, from 15.20 to 20.40 per cent. of the ash. We have appended the report of these four analyses as well as of the three of the ashes of the tobacco stalk, for reference and comparison. It will be seen that the percentage of ash to the dried stalk is from 8.72 to 10.72; the proportion of *potash* in the ashes of the stalk is from 27.48 to 40.12 per cent.; that of *lime* from 11.84 to 23.88 per cent., and that of *phosphoric acid* from 10.28 to 12.52 per cent.; provided the figures are correctly printed; for, it will be seen, there is such a remarkable *identity* of the figures (in the columns

No. 1 *a* and No. 3 *a*,) representing the proportions of the potash, soda, lime, magnesia, phosphoric acid, sulphuric acid, and chlorine, even to the smallest decimal fraction, (except in the lime,) that it is very probable some error in copying has occurred. The probability that two similar analyses should give so exactly the same figures in the results, in seven different ingredients, being quite small.

METHOD OF ANALYSIS OF THE TOBACCO ASH.

The method of analysis followed may be thus described: The various samples of tobacco, in the original small bundles of leaves, or "hands," were freely exposed, in a dry room where a fire was kept daily, until they were all thoroughly air-dried. It was found that when thus equally exposed they differed much in their apparent dryness; some samples being crisp and brittle, whilst others remained permanently soft and flexible; especially those which contained much chlorides. An average leaf* was now cut into small pieces, midrib and all, and weighed before and after exposure, for a day or more, to the temperature of boiling water in the water-bath. The loss of weight observed indicated the *moisture* of the air-dried leaf.

The dried leaf was then carefully burnt to ashes, with the lowest possible heat, in a large platinum capsule, over a spirit lamp; and the *ash*, cooled over sulphuric acid, was weighed.

The ash, not always perfectly white, was now digested in pure diluted nitric acid at a moderate heat, and, after a sufficient time, the undissolved residue, separated, washed, and dried, was weighed. This residue consists of *sand*, *silica*, and unburnt *carbon*. The amount of the latter was ascertained by burning, and was excluded from the weight of the ash, as was also the *sand*, by the process mentioned above.

The clear acid solution was now carefully divided into five equal parts by means of a pipette. One portion was evaporated to dryness, for the estimation of the dissolved *silica;* which was added to that which was left undissolved by the diluted nitric acid. Another portion was used for the estimation of the *sulphuric acid*, by nitrate of baryta, &c.

The third portion was employed for the estimation of the *phosphoric acid*, by the use of molybdate of ammonia, &c. In the fourth portion the *chlorine* was estimated, in the usual way.

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* Of the small samples two or three leaves were taken.

The fifth portion was used for the *general analysis;* pretty much in the manner described in the third volume of these Reports, under the head of soil analysis; with this difference, that the first precipitate, produced by the addition of ammonia, containing the *phosphates,** &c., after being dried and weighed, was dissolved in the smallest quantity of hydrochloric acid, and then sulphuric acid and alcohol were added to separate the *lime* as *sulphate,* by which means the amount of *phosphate of lime* (tri-basic) was calculated. The acid, alcoholic, filtrate, evaporated nearly to dryness, was now super-saturated with ammonia, which gave a precipitate of phosphates of magnesia and iron, &c. This mixed precipitate was dissolved in a small quantity of hydrochloric acid, and the *oxides of iron and manganese* separated from the *magnesia,* &c.

A separate estimation of the phosphoric acid was made by the use of the ammoniacal-sulphate of magnesia to the appropriate filtrates.

The results of these thirty analyses are as follows; given in the tabular form, and arranged, as nearly as possible, according to the geological formation in which the tobacco was grown. Beginning, however, with Cuba and Florida tobacco, which have been placed in the first table for comparison.

TABLE I (*a.*) *Composition of the ashes of Cuba and Florida Leaf Tobacco. In* 100 *parts of the air-dried leaf.*

	No. 1. Cuba.	No. 2. Florida.	Average.
Potash	4.5249	5.9015	5.2432
Soda	.3782	.1222	.2502
Lime	5.6258	2.9889	4.3073
Magnesia	1.3590	2.1581	1.7585
Oxides of iron and manganese	.3024	.0401	.1712
Phosphoric acid	1.0788	.4240	.7512
Sulphuric acid	.2676	.4565	.3620
Chlorine	1.3748	.8212	1.0980
Silica	.3508	.2024	.2766
Carbonic acid and loss	5.4952	3.8178	4.6269
Per cent. of ash in the air-dried leaf	20.7575	16.9327	18.8451
Per cent. of moisture in the air-dried leaf	11.2411	11.1764	----------
Per cent. of phosphate of lime in the air-dried leaf	1.2063	.2087	----------
Per. cent. of phosphate of magnesia in the air-dried leaf	.2202	.2445	----------

* In consequence of the large quantity of lime and magnesia in tobacco ash, they contain all the phosphoric acid.

No. 1. Cuba Leaf Tobacco, imported by Mr. Meyer, cigar manufacturer, Lexington. Leaves quite small; of a light greenish-brown color. Flavor said to be exceedingly good in smoking.

No. 2. Florida Leaf Tobacco, also imported by Mr. Meyer; leaves very small, smaller than those of the Cuba, and of greenish-brown color, with numerous small, rounded, light-colored spots upon them. Flavor very mild and pleasant when smoked.

The leaves of both these specimens were much smaller and thinner than those of most kinds of Kentucky tobacco, and were not gummy on their surfaces.

It will be observed that the Florida tobacco leaf contains but a small proportion of *lime*, but more than makes up its proportion of alkaline earths by its large quantity of magnesia. Although the percentage of its ash is small, it contains more *potash* than any other tobacco examined.

TABLE II (a.) TOBACCO PRODUCED ON SOIL BASED ON THE LOWER SILURIAN FORMATION.

	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	Average.
Potash	3.7811	4.9197	6.0155	4.6008	5.4248	5.1309	5.1726	5.9134	6.1241	4.8926	5.1170
Soda	1.1531	.2436	trace.	1.6448	.0244	.4025	.0828	.1810	.3701	.3404	.4267
Lime	5.6612	3.9417	5.7572	7.8798	3.6613	5.3580	4.6630	4.5119	3.8658	4.1672	4.6335
Magnesia	.7266	.4498	.4560	1.1372	.5905	.7991	.6112	.4221	.6808	.7435	.6981
Oxides of iron and manganese	.0369	.0457	.0480	.0434	.0375	.0635	not est.	.0596	.1645	.0223	.0335
Phosphoric acid	.5701	.6809	1.0090	.5395	.4797	.5164	.6130	.4512	.6441	.4063	.5089
Sulphuric acid	.6802	.5268	1.0382	.6359	.5539	.5756	.5799	.5217	.5941	.4499	.5415
Chlorine	.0609	.0750	.0828	.0749	.2557	.0324	.0733	.0723	.0154	.0340	.0583
Silica	1.6724	.1453	.7168	.1622	.2297	.1456	.3074	.5029	.0442	.1372	.2868
Carbonic acid and loss	3.8401	4.7691	5.3052	5.6785	4.5818	6.1976	4.9856	4.0867	5.6414	6.1518	5.4493
Per cent. of ash in the air-dried leaf	18.1826	15.7976	20.4287	22.3970	15.8393	19.2246	17.1068	16.7138	18.1445	17.3452	17.7736
Per cent. of moisture in the air-dried leaf	11.8820	11.5801	9.0311	9.1357	10.6180	9.5169	10.0082	10.4393	11.9069	11.5773	--------
Per cent. of phosphate of lime in the air-dried leaf	.9725	.9692	2.1964	1.0197	.6149	.7812	1.0522	.7756	1.2421	1.0519	--------
Per cent. of phosphate of magnesia in the air-dried leaf	.0813	not est.	.0208	not est.	not est.	.0404	not est.	no est.	.0673	.4212	--------

No. 3. Mason County Cigar Leaf Tobacco; which received the premium from the Kentucky State Agricultural Society in 1856. Obtained by R. W. Scott, Esq., from the State Agricultural Society rooms at Frankfort; from whence were procured all the specimens included in this table, except Nos. 11 and 12, which were obtained, by the kindness of Mr. Spratt, from Pickett's Tobacco Warehouse, Louisville.

No. 4. "Maryland Bay Cigar Tobacco," raised in Bracken county by Dr. J. Bradford.

No. 5. "Leaf Tobacco," raised on bottom land, in Mason county. Presented to Kentucky State Agricultural Society by Hon. L. J. Bradford.

No. 6. "Leaf Tobacco," raised on hill land in Mason county. Presented as above.

No. 7. "Mason County Shipping Tobacco." Premium from Kentucky State Agricultural Society in 1857.

No. 8. "Mason County Leaf Sample." Premium from Kentucky State Agricultural Society in 1856.

No. 9. "Mason County Cigar Tobacco," raised by L. J. and J. T. Bradford, in Bracken county, Ky.

No. 10. "Bracken County Tobacco," raised by Hon. L. J. Bradford.

No. 11. Premium Cigar Tobacco. Mason county. From Pickett's Warehouse, No. 9981.

No. 12. Trimble County Cigar Tobacco. From Pickett's Warehouse, No. 9976.

These were very fine samples of the best leaf tobacco of Mason, Bracken, and Trimble counties. Some of them having received premiums on public exhibition. The leaf is generally much larger than those of the Cuba and Florida tobaccos, but usually quite thin, silky, and free from gummy matter; and of a rich brown or bright yellowish brown color.

TABLE III (*a*.) *Tobacco produced on soil based on the silicious mudstone beds of the Lower Silurian formation.*

	No. 13.	No. 14.	Average.
Potash	4.2725	3.1155	3.6940
Soda	.1818	.1582	.1700
Lime	2.1154	3.7693	2.9423
Magnesia	1.0909	1.3037	1.1973
Oxides of iron and manganese	.0418	.0920	.0669
Phosphoric acid	.6363	.4247	.5305
Sulphuric acid	.8481	.4716	.6598
Chlorine	.5518	.0460	.2989
Silica	.1291	.2464	.1878
Carbonic acid and loss	2.8008	4.0865	3.4337
Per cent. of ash in the air-dried leaf	12.6685	13.7139	13.1812
Per cent. of moisture in the air-dried leaf	9.8950	12.5434	----------
Per cent. of phosphate of lime in the air dried leaf	.8990	.4745	----------
Per cent. of phosphate of magnesia in the air-dried leaf	.3600	.1400	----------

No. 13. Owen County Tobacco. (Manufacturing.) From Pickett's Warehouse, No. 9,998. A very strong tobacco; leaves large; dark-brown; quite gummy.

No. 14. Gallatin County Tobacco. (Cutting tobacco?) From Pickett's Warehouse, No. 347. Leaves of moderate size; brown and flexible. A strong tobacco of pleasant flavor, when smoked.

TABLE IV (*a*.) TOBACCO, GROWN PRINCIPALLY ON SOILS BASED ON SUB-CARBONIFEROUS STRATA.

	No. 15.	No. 16.	No. 17.	No. 18.	No. 19.	No. 20.	No. 21.	No. 22.	No. 23.	Average.
Potash	4.4602	4.1870	3.6110	3.9633	3.6406	4.9107	4.7302	3.9242	3.2261	4.0726
Soda	.3292	.2436	trace.	trace.	.0605	.3736	.1561	.0768	.1263	.1951
Lime	3.6075	4.5594	3.3243	4.7895	5.3667	4.8124	3.9402	5.2749	4.8724	4.5052
Magnesia	.6382	.6218	.5949	.9356	.2178	.5700	.5988	.6006	.5402	.5909
Oxides of iron and manganese	.0223	.0793	.0204	.0538	.0227	.0224	.0199	.0256	.0403	.0384
Phosphoric acid	.8814	.7730	.4170	.3725	.4245	.5882	.2791	.3866	.5358	.5175
Sulphuric acid	.1805	.7119	.4520	.3778	.3998	.3288	.3888	.2916	.4395	.3967
Chlorine	.0186	.0900	.1720	.2233	.0396	.1345	.0397	.0248	.3161	.1175
Silica	.4354	.2816	.2333	.3231	.4070	.2957	.1816	.2288	.4999	.3207
Carbonic acid and loss	3.7844	4.6643	3.6324	5.7843	6.5421	6.1074	5.6904	6.1672	4.5808	5.1696
Per cent. of ash in dried leaf	14.3577	16.2119	12.4573	16.8232	17.1213	18.1437	16.0248	17.0011	15.1774	15.9242
Per cent. of moisture in dried leaf	11.7665	11.4956	12.7819	4.8813	12.8754	12.4794	14.0732	11.9501	11.2481	....
Per cent. of phosphate of lime in dried leaf	1.5072	1.1603	.5783	.4590	.6079	.8914	.4531	.5329	.9806	....
Per cent. of phosphate of magnesia in dried leaf	.0527	.1429	.1234	.2101	.1086	.1025	.1381	.0999	.0805	....

No. 15. "*Barren County Tobacco;*" from the State Agricultural rooms at Frankfort. A bright colored tobacco: tough and flexible; leaves of a moderate size. A strong, pungent tobacco, when smoked.

No. 16. "*Hart County Premium Manufacturing Tobacco.*" No. 9934, Pickett's Warehouse, Louisville. Moderate sized leaf; mottled brownish and yellowish. Very strong tobacco.

No. 17. "*Green County Tobacco.*" No. 10,000, Pickett's Warehouse. A bright-yellowish-brown flexible leaf; suitable for cigars. ("Probably from Spanish seed.") A pretty mild tobacco.

No. 18. "*Meade County Tobacco.*" No. 9,953, Pickett's Warehouse. Of a rich yellowish-brown color; "very mild, but not of a very pleasant taste," when smoked. Cigar tobacco?

No. 19. "*Simpson County Tobacco.*" No. 42, Pickett's Warehouse. Rather a large leaf, flexible; of a yellowish-brown color; "when smoked, of a very strong and unpleasant taste." *Shipping tobacco?*

No. 20. "*Taylor County Tobacco.*" No. 312, Pickett's Warehouse. Quite a small leaf; not very tough; of a light yellowish-brown and greenish color. Very mild and pleasant when smoked. *Cutting tobacco?*

No. 21. *Larue County Tobacco.* No. 310, Pickett's Warehouse. O bright, very light yellowish brown, or brownish yellow color. Leaves of moderate size, quite flexible. Very mild when smoked. A cigar tobacco?

No. 22. "*Hardin County Tobacco.*" No. 9994, Pickett's Warehouse. Leaves of a good size; yellowish-brown and greenish; not very flexible. Strong and pungent when smoked. *Manufacturing tobacco.*

No. 23. "*Christian County Premium Shipping Tobacco.*" No. 10,008, Pickett's Warehouse. Leaves of moderate size; dark brown. "Moderately strong; rather pleasant for smoking."

TABLE V (*a*.) TOBACCO GROWN PRINCIPALLY ON QUARTERNARY SOIL; GENERALLY WITH COAL MEASURES SUB-STRATA.

	No. 24.	No. 25.	No. 26.	No. 27.	No. 28.	No. 29.	No. 30.	Average.
Potash	3.2494	3.6006	3.4350	3.5515	3.2636	3.6845	2.6889	3.3534
Soda	.7476	.0527	.0958	.2074	.1247	.0853	.0642	.1540
Lime	3.8650	4.2502	3.0001	4.3399	4.2558	3.8001	2.9179	3.7756
Magnesia	.5259	.7374	1.4985	1.9703	1.0888	1.0886	1.0075	1.1310
Oxides of iron and manganese	.0967	.1219	.0158	.0284	.0269	.1435	.0171	.0643
Phosphoric acid	.7503	.6726	.5649	.3431	.5518	.6815	.4321	.5710
Sulphuric acid	.4050	.4825	.3155	.3000	.607	.3542	.5716	.4336
Chlorine	.1894	.4158	2.4085	.0831	.6381	.1435	.2494	.5897
Silica	1.6232	.5090	.2661	.2[illegible]94	.1194	.4469	.1623	.4800
Carbonic acid and loss	3.7717	3.4255	1.8050	3.1475	3.5034	2.7131	4.0363	3.0231
Per cent. of ash in air-dried leaf	15.2242	14.2682	13.4052	14.2106	14.1801	13.1352	12.1473	13.5758
Per cent. of moisture in air-dried leaf	7.8086	11.5883	12.3912	10.8037	12.0412	10.9696	12.8832	---------
Per cent. of phosphate of lime in air-dried leaf	1.0638	1.2708	.7334	.6080	1.0976	.5665	.6473	---------
Per cent. of phosphate of magnesia in the air-dried leaf	.3188	.1995	.0088	.3061	.6381	.2624	.0742	---------

No. 24. "*Henderson County Manufacturing Tobacco. Premium from Kentucky State Agricultural Society*, 1856." Leaves of a moderate size; brown. "A mild tobacco, but not very pleasant when smoked."

No. 25. "*Henderson County Leaf Sample. Premium to W. S. Elam, by Kentucky State Agricultural Society*." Leaves large, dark brown; tough. "A strong tobacco when smoked."

No. 26. "*Henderson County Leaf Cigar Tobacco. Premium to W. S. Elam, by the State Agricultural Society*, 1857." Leaves large; brighter colored than the preceding; quite flexible and tough. "A very pleasant and mild smoking tobacco."

No. 27. "*Henderson County Leaf Manufacturing Tobacco. Premium to T. J. Lockett by Kentucky State Agricultural Society*." Leaves large; of a rich yellowish-brown color; somewhat flexible. "A weak tobacco when smoked."

No. 28. *Henderson County Shipping Tobacco. Premium to W. S. Elam, from Kentucky State Agricultural Society*." Leaves large; of a handsome yellowish-brown color; somewhat flexible. "Very strong when smoked."

No. 29. *Daviess County Premium Cutting Tobacco. Pickett's Warehouse, No.* 10,010." Leaf of a moderate size; dark brown and greenish; not very flexible. "A very strong and pungent tobacco when smoked."

No. 30. "*Graves County Cutting Tobacco. Pickett's Warehouse, No.* 285." Leaves quite large and heavy; dark-brown; quite flexible, and somewhat gummy. "Moderately strong, but quite sweet and pleasant when smoked."

TABLE VI (*a*.) *Average Composition of the Ash of the whole thirty samples of Tobacco.*

Potash	4.2960
Soda	.2392
Lime	4.0328
Magnesia	1.0752
Oxides of iron and manganese	.0549
Phosphoric acid	.5753
Sulphuric acid	.4787
Chlorine	.4325
Silica	.3104
Carbonic acid and loss	4.3645
Percentage of ash in the air-dried leaf	15.860

TABLE VII (a.) COMPOSITION IN 100 PARTS, AND PROPORTIONS OF OXYGEN IN THE BASES, OF THE THIRTY TOBACCO ASHES.

No.	COUNTY, &c.	Potash.	Soda.	Lime.	Magnesia.	Oxid's of iron and manganese.	Phosp'oric acid.	Sulphuric acid.	Chlorine.	Silica.	Carbonic acid and loss.	Oxygen in the bases.
1	Cuba tobacco	21.80	1.82	27.10	6.55	1.46	5.90	1.29	6.62	1.69	26.47	14.93
2	Florida tobacco	34.84	.72	[illegible]	12.75	.24	2.50	[illegible]	[illegible]	1.19	22.55	16.28
3	Mason county tobacco	20.79	6.34	31.14	4.00	.90	3.14	3.74	.33	9.2	[illegible]	15.67
4	Bracken county tobacco	31.14	1.54	24.94	2.85	.29	4.31	[illegible]	.47	.92	31.19	14.10
5	Mason county tobacco	20.44	trace.	28.18	2.23	.24	4.94	[illegible]	.41	3.51	25.97	14.01
6	Mason county tobacco	20.54	[illegible]	[illegible]	[illegible]	.19	2.41	[illegible]	.33	.73	25.36	17.44
7	Mason county tobacco	34.25	.15	23.12	3.73	.24	3.03	3.49	1.61	1.45	28.93	13.96
8	Mason county tobacco	26.69	2.09	27.87	4.16	.33	2.69	[illegible]	.17	.76	32.23	14.73
9	Mason county tobacco	30.24	.48	27.26	[illegible]		3.58	3.4	.43	1.80	29.14	14.43
10	Bracken county tobacco	35.38	1.08	26.99	2.53	.36	2.70	3.07	.43	3.00	24.45	15.07
11	Mason county tobacco	33.75	2.14	21.31	3.75	.91	3.55	3.27	.18	.24	31.10	13.69
12	Trimble county tobacco	28.21	1.96	24.03	4.29	.13	2.34	2.59	.19	.79	35.47	13.86
13	Owen county tobacco	33.72	1.44	16.70	8.61	.13	5.02	6.69	4.36	1.03	22.11	14.68
14	Gallatin county tobacco	22.72	1.15	27.49	9.51	.67	3.10	3.44	.33	1.79	29.80	15.95
15	Barren county tobacco	31.06	2.29	25.13	4.45	.16	6.14	1.26	1.30	3.03	26.86	14.80
16	Hart county tobacco	25.83	1.50	28.13	3.84	.49	4.76	4.39	.55	1.74	28.77	14.45
17	Green county tobacco	28.99	trace.	26.68	4.78	.16	3.36	3.03	1.08	1.87	29.16	14.63
18	Meade county tobacco	23.56	trace	24.47	[illegible]	.32	2.22	2.25	1.33	1.92	34.38	13.28
19	Simpson county tobacco	21.26	.35	[illegible]	1.27	.13	2.46	2.34	.23	2.38	38.21	13.16
20	Taylor county tobacco	27.07	2.16	26.52	3.14	.12	3.24	1.81	.74	1.63	33.67	14.31
21	Larue county tobacco	29.52	.96	24.51	3.74	.13	1.74	2.43	.25	1.13	35.50	14.79
22	Hardin county tobacco	23.08	.45	31.03	3.53	.15	2.27	1.72	.15	1.34	36.28	14.31
23	Christian county tobacco	21.26	.83	32.10	3.56	.26	3.53	2.90	2.08	3.29	30.19	14.43
24	Henderson county tobacco	21.74	4.91	25.39	3.45	.64	4.93	2.67	1.24	10.66	24.77	15.17
25	Henderson county tobacco	25.24	.37	29.79	5.17	.85	4.71	3.38	* 2.92	3.57	24.10	14.93
26	Henderson county tobacco	25.64	.71	22.38	11.18	.12	4.21	2.35	17.92	1.98	13.47	15.40
27	Henderson county tobacco	24.99	1.46	30.54	13.87	.20	2.41	2.11	.59	1.68	22.15	17.90
28	Henderson county tobacco	21.01	.88	30.01	7.68	.19	3.89	4.29	[illegible]	.84	24.71	15.79
29	Daviess county tobacco	28.05	.65	28.93	8.29	1.09	5.19	2.70	1.09	3.36	29.65	16.79
30	Graves county tobacco	22.14	.53	24.02	8.29	.14	3.56	4.71	2.05	1.34	33.23	14.08
	Average proportion of oxygen in the bases of the thirty samples											14.83

(See under Bracken and Mason counties for remarks on tobacco soil, culture, &c., &c.)

For the sake of comparison I append a summary of the analyses of *tobacco ashes* by Dr. Chas. T. Jackson, reported in Patent Office Reports, 1858, (*Agriculture*,) viz: four of the ash of the *leaves* and three of the ash of the *stalk* of the tobacco, as follows :

No. 1. "*Locality, Massachusetts ; Hatfield, Connecticut river. Farm of W. H. Dickinson. Sample from the best soil.*" (Ash of the leaves.)

No. 2. "*Locality, Massachusetts. Town of Whatley, Connecticut river, farm of J. Allis. Tolerably good soil.*" (Ashes of the leaves.)

No. 3. "*Locality, Maryland. Prince George's county. Richest soil.*" (Ashes of leaves.)

No 4. "*Locality, Maryland. Prince George's county. Much worn soil.*" (Ashes of leaves.)

No. 1 (*a*.) *Ashes of the stalk of sample No.* 1.

No. 3 (*a*.) *Ashes of the stalk of sample No.* 3.

No. 4 (*a*.) *Ashes of the stalk of sample No.* 4.

	No. 1. Leaf.	No. 2. Leaf.	No. 3. Leaf.	No. 4. Leaf.	No.1 (*a*.) Stalk.	No.3 (*a*.) Stalk.	No.4 (*a*.) Stalk.
Potash	20.40	15.20	17.60	20.32	40.12	40.12	27.48
Soda	6.03	2.52	1.40	4.36	9.20	9.20	7.28
Lime	25.75	28.99	22.66	25.85	11.84	11.48	23.88
Magnesia	1.60	.60	8.00	2.00	.80	.80	.40
Oxides of iron and manganese	1.20	1.60	2.80	1.20	2.00	1.40	1.30
Phosphoric acid	7.60	9.05	8.50	7.15	12.52	12.52	10.28
Sulphuric acid	2.75	2.72	8.00	1.52	2.04	2.04	4.48
Chlorine	1.68	.72	3.76	.92	2.96	2.96	3.12
Silica and silicious sand	9.60	29.40	8.60	21.20	.40	2.10	3.20
Carbonic acid and loss	23.39	9.20	18.68	15.48	16.12	17.08	18.58
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent. of ash in dried leaf or stalk	18.92	20.20	14.53	14.76	10.72	9.20	8.72

Such a close and extraordinary resemblance appears in the two columns of figures under Nos. 1 (*a*) and 3 (*a*,) that it is probable some errors of copying have occurred.

CHEMICAL EXAMINATION OF NATIVE WINES, MADE FROM CATAWBA AND HERBEMONT GRAPES.

One sample of the Catawba wine analyzed was made by myself, in the autumn of 1857, from grapes grown by Mr. Foley, Fayette county, Ky., which, in consequence of a severe drought, had not filled and ripened well. The juice was fermented in a glass bottle, air having been entirely excluded during the process, by a tight cork, sealed, through which was inserted a syphon-like bent glass tube, with its outer end immersed in water in a vial, to allow the carbonic acid to escape which was produced in the fermentation. The specific gravity of the fresh juice was not taken; but that of some from Catawba grapes grown in my garden in 1855 was found to be 1.070.

The wine obtained was almost colorless; having only a very light reddish tint. The juice having been immediately separated from the skins and seeds of the grapes in moderately pressing them. The taste of the wine is quite acid, but pleasant; and the *bouquet* is remarkably fine.

The other specimen of Catawba wine examined was procured for me, by the kindness of Jos. M. Locke, M. D., of Cincinnati, from the cellars of Mr. N. L. Longworth. This is apparently an old wine, quite sound, and of a pale sherry color.

The *Herbemont wine* analyzed was also obtained from Mr. Longworth by Dr. Locke. Its color is yellowish, like that of cider. The *bouquet* is not as pleasant as that of the Catawba wine; but somewhat like that of some kinds of Rhine wine. It contains a little *aldehyde*, the result of a commencement of acetification, and was found to yield a small quantity of *acetic acid* on analysis. It was evidently beginning to turn to vinegar.

The results of the examinations of these three samples of wine may be tabulated as follows:

	My Catawba. wine.	Longworth's Catawba.	Longworth's Herbemont.	Nierstein wein. 1842.
Specific gravity	0.995	------	------	0.995
Per cent. of alcohol	8.590	10.690	10.660	11.500
Per cent. of solid extract	1.748	1.850	1.380	1.900
Per cent. of ash	.145	.130	.140	.130
Quantity of caustic soda to neutralize 100 parts of wine	.404	.371	.364	.270

For comparison I have placed in the above table the results, given by **Diez, (quoted by Mulder, "*Die Chemie des Weins*," f. 188,) of his exami-**

nation of the *Nierstein wine*, which, amongst the Rhine wines he analyzed, most nearly resembles our Catawba in composition. Our wine will be seen, however, to contain a little less alcohol, and much more acid than that. The free acid in the first sample of Catawba above, amounts to about one per cent., and is not disguised in the wine by any remains of sugar; as the most delicate tests could not detect the smallest quantity of that substance in it. A small amount of sweetish substance is, however, contained in what is called the *extractive matter*, which, no doubt, has been sometimes mistaken for sugar, and which, according to the recent observations of M. Pasteur, communicated to the French Academy, is *glycerine*, always produced in the vinous fermentation in company with a small quantity of succinic acid. The percentage of free acid in the Rhine wines is less than this, in the best kinds; it being, according to Schubert, (Mulder, *Chem. des Weins*, f. 190,) generally from 0.8 to 0.9 per cent., and mollified by the presence of a larger proportion of *extractive matters*, containing a small quantity, less than one per cent., of sugar or glycerine.

The quantity of grape-sugar in the fresh juice which furnished these three specimens of native wine must have been from about 17. to 22. per cent. We are told by Mulder, from the best authorities, that the average amount of grape-sugar in grape juice, from all the various wine countries, varies from 13 to 30 per cent. According to Fontenelle, the juice of the grapes in the south of France contains from 18 to 30 per cent. of sugar; whilst according to Chaptal it varies from 15 to 20 per cent. in the more northern vineyards. On the Rhine it varies from 13 to 25 per cent. When we understand that all the *alcohol* of the wine is derived from the *sugar;* of which it produces about half its weight by complete fermentation; it is easy to see that the more sugar is contained in the unfermented juice, within certain limits, the stronger the wine will be. At or above 40 per cent. of sugar, however, the fermentation proceeds very slowly; and the large quantity of alcohol resulting puts an end to the process before all the sugar is decomposed.

The stronger varieties of wine, as Madeira, Port, and Sherry, which contain 20 per cent. and upwards, of alcohol, have usually been strengthened, after the fermentation is over, by the addition of brandy. The weaker varieties of wine, as certain kinds of German, French, and Dutch wines, contain only from about 6 to 10 per cent. of alcohol.

When the percentage falls below 8 per cent., it is very difficult to prevent acetification; and the finest kinds of these wines contain from 9 to 13 per cent. of alcohol; produced from a proportionate amount of sugar in the grape juice. Understanding these facts, the French have learned to equalize the quality of their wines, by adding *grape-sugar*, made from potato starch, to the acid juice of the imperfectly ripened grapes of unfavorable seasons.

This could very properly be done in the manufacture of our Catawba wine; although a prejudice exists against the addition of sugar to the grape juice; based, probably, on the idea that ordinary *cane* sugar and the natural sugar of the grape, (*grape-sugar* or *glucose*,) are different substances. But the *cane-sugar* changes speedily into *grape-sugar* under the influence of the *acid* of the grape juice; and it is not known that the products of its fermentation are at all different from those of the sugar naturally contained in the grape. If, then, *brown* sugar, or any other kind which has a *peculiar flavor*, be avoided; or if the pains be taken to manufacture pure *grape-sugar* from starch, as is done in France, the addition of the *pure* sugar, in proper quantity, to the too acid juice of bad seasons, would greatly improve the wine, and not be liable to any objections. This means could also very properly be employed to manufacture *stronger* wines than can be produced from the native grape juice alone.

The solid materials and the acids of the above wines were found to be in the following proportions in 100 parts of the wine, viz:

	My Catawba.	Longworth's Catawba.	Longworth's Herbemont.
Tartaric acid and racemic acids	0.5749	0.5120	0.2756
Malic acid	.2189	.2427	.2253
Citric and tannic acids	traces	traces.	traces.
Extractive matters	.0800	not estim'd.	not estimated.
Gum	.0060		
Albumen, coloring, and fatty matters	not estimated.	not estimated.	not estimated.
Acetic acid	none.	traces.	.2869
Sugar	none.	none.	none.

Some loss of the acids occurred in the processes for their separation, judging from the quantity of caustic soda required to neutralize the wine. It is believed that they contain notable quantities of *racemic acid*, replacing an equal amount of the tartaric acid usually found in grape juice.

The *ash* obtained on thoroughly burning the *solid extract* left by the evaporation of the wine, was also analyzed, in these three samples; and the results are as follows:

COMPOSITION OF THE ASH OF WINE.

	My Catawba.	Longworth's Catawba.	Longworth's Herbemont.
Potash	0.0357	0.0439	.0320
Soda	.0160	.0060	.0100
Lime	.0045	.0023	.0029
Magnesia	.0117	.0106	.0150
Oxide of iron	trace.	trace.	trace.
Phosphoric acid	.0095	.0015	.0035
Sulphuric acid	.0219	.0105	.0120
Chlorine	.0003	.0023	.0029
Silica	.0021	not estimated.	not estimated.
Carbonic acid and loss	.0433	.0529	.0617
Ash of 100 parts of the wine	0.1450	0.1300	0.1400

The quantity of *mineral matters* derived, from the soil, which is retained in the wine, when it has become completely clear after perfect fermentation, is quite small; amounting only to about one seventh of one per cent.!

A great deal of the *potash, lime, magnesia, &c.*, originally contained in the grape juice, separates as *lees*, as the fermentation progresses, and finally settles to the bottom of the wine cask: forming the *crude tartar;* from which we obtain all the tartaric acid and cream of tartar of commerce. If these lees, as well as the leaves and shoots of the vine removed in pruning, &c., and the husks, stems, and seeds, be restored to the soil, and nothing carried away but the wine, vine culture would prove much less exhausting to the soil than any other kind of *hoed* crop. Some comparative calculations on this subject will be given at the end of this appendix.

According to Boussingault, (Ann. de Chem. et de Phys., 3me Serie, Tome 30, p. 369,) the quantities of mineral materials in the ashes of the unfermented juice of the grape, from his own vineyard, in Alsace, are as follows, in the hundred parts of the juice, viz:

Potash	0.842
Lime	.092
Magnesia	.172
Phosphoric acid	.412
Sulphuric acid	.096
Chlorine	trace.
Silica	.006
Carbonic acid	.250
	1.870

Amounting, in all, to nearly two per cent. of the weight of the juice.

The *stalks and branches of the vine* contain considerable proportions of potash, lime, and phosphoric acid, yielding from above *two* to more than *three per cent. of their weight of ashes.* The following is about an average account of the *composition of the ash*, according to Bruchauer:

Potash	34.1
Soda	7.6
Lime	32.2
Magnesia	4.7
Oxide of iron	.2
Phosphoric acid	16.4
Sulphuric acid	2.7
Chloride of sodium	.8
Silica	1.5

The leaves contain a large percentage of mineral matters, derived from the soil. But both leaves and prunings should be left to decay on the soil, for which, according to experience in Europe, they are the best manure in the cultivation of the vine.

BLEEDINGS OF THE GRAPE-VINE.

In the spring of 1860, the writer caused to be collected a quantity of the "bleedings" of a *Lenoir* grape-vine, from a branch which had been cut off for the purpose; with a view to ascertain by analysis, whether any notable quantity of the essential materials of the soil, &c., was contained in it. The result was as follows:

One hundred parts of the clear colorless fluid evaporated to dryness at 212° F., left 0.286 per cent. of *extract* which was of a light-chestnut color, and contained a vegetable substance resembling gum. This, when incinerated, left 0.084 per cent. of *ashes*, so that the amount of the *organic matters* was 0.202 per cent. The *composition of the ashes* was found to be as follows:

Carbonate of lime	0.0419
Magnesia	.0057
Phosphoric acid	trace.
Sulphuric acid	.0027
Potash	.0240
Soda	.0004
Silica	.0048
Loss	.0045
	0.0840

So that, as might have been expected, this sap of the vine contains a portion of those mineral materials which are essential to vegetable nourishment.

CHEMICAL INVESTIGATION INTO THE COMPOSITION OF THE ASHSE OF THE GRAIN AND COB OF INDIAN CORN, AND THE PROPORTION OF OIL CONTAINED IN THE GRAIN.

This examination was commenced with a view to ascertain whether any difference in the quantity or composition of the *mineral constituents* of the grain, or, in the proportion of the *fatty matter*, could be observed in the corn grown on very poor land, as compared with that raised in the rich blue limestone region of central Kentucky. It being well known that the food produced on these rich lands is peculiarly conducive to the nourishment and fattening of animals, and that those of this favored region, like the vegetables on which they feed, appear of a larger growth, more fully developed, and in better condition, generally, than those produced on the poorer lands of the State. This may be supposed to be owing to the greater abundance of food in the rich land; the vegetable growth being stimulated by the greater quantity of the nutritive mineral elements which are present in the soluble condition in the soil; but, on the other hand, investigations into the composition of the ashes of the tobacco plant have demonstrated that there may be a marked difference in the *quantity* as well as in *composition* of the mineral ingredients of the same plant grown on different soils.

The specimens obtained for this comparative examination are described as follows:

No. 1 (*c.*) "*Indian Corn, grown on the farm of Richard Collins, on an old worn out and very poor field. 'Old Scott place,' two miles east of Hardinsburg, Breckinridge county, Kentucky. Soil, the waste of the second sandstone above the base of the millstone grit; the surface of the field being well covered with small fragments of that bed.*"

Average length of the ears about seven inches. The corn from six and a half ears weighed two pounds six ounces avoirdupois. The produce was about eight to twelve bushels per acre; the season having been unfavorable. This is a yellowish-red corn, said to be more productive on poor land than the white varieties. This specimen was procured at my request, for this especial purpose, by the able Topographical Assistant, S. S. Lyon, Esq., who was desired to select corn from the poorest field he met with in his extensive perambulations of the State.

No. 2 (*c*.) "*Indian Corn from the farm of Christopher Keiser, six miles from Lexington, on the Henry's Mill turnpike, Fayette county, Ky. Grown on the rich land of the Blue Limestone of the Lower Silurian formation.*"

Produce about seventy-five bushels to the acre, the season having been unfavorable. Average length of the ears about seven and a half inches. Weight of the corn on five ears, three pounds and a half, avoirdupois: weight of the cob about one sixth that of the corn; the ears being well dried. A white dent corn.

A quantity of each of these two specimens was ground to meal in a hand mill; a portion of each carefully incinerated for the purpose of the ash analyses; and another, larger, portion treated with ether, in a displacement apparatus, for the separation and estimation of the fatty matter, or oil.

The results obtained were as follows:

IN 100 PARTS OF THE THOROUGHLY AIR-DRIED CORN.

	No. 1 (*c*.)	No. 2 (*c*.)
Yellowish oil	4.600	5.260
In the ashes—		
Potash	0.2840	0.2878
Soda	.0854	.2204
Lime	.0052	.0076
Magnesia	.0713	.1287
Oxides of iron and manganese	not est.	not est.
Phosphoric acid	.3513	.4230
Sulphuric acid	.0165	trace.
Chlorine	not est.	not est.
Silica	.0150	.0250
Carbonic acid and loss	.1513	.3195
Total ash in 100 parts of the dried corn	0.9800	1.4120
Proportion of phosphate of lime	0.0093	0.0139
Proportion of phosphate of magnesia	0.1984	0.3584
Proportion of phosphoric acid combined with the alkaline	0.1488	0.1870

Of course no *positively certain* conclusion can be attained by means of a single pair of analyses alone; but as far as these go, they show the superior nourishing and fattening qualities of the corn grown on the rich ground, as compared, *in equal weights of the corn,* with that raised on poorer land; and thus give a new motive to farmers to keep their ground in good condition. In short, the corn from Fayette county, not only

gives a larger proportion of oil, and of mineral substances in the form of ash, but the potash, lime, magnesia, phosphoric acid, and silica, are all in larger amount in this; and only in the single ingredient, the sulphuric acid, does the corn from the poor ground exceed this in its quantity of essential mineral matter.

Some of the difference observed may possibly be due to the *different varieties* of corn; how much cannot be determined without careful chemical analysis of corn of these two kinds grown on the same ground. But the reddish yellow corn is generally considered, by farmers, richer in oil and stronger as food for animals, than the white corn; and the probability is that the difference of composition, shown above, is due more to the soil than the variety of corn grown on it.* In corroboration of this view, I may refer to three analyses by Emmons and Salisbury, (Natural History of New York, (Agriculture,) Part V, Vol. II, p. 249,) of the ashes of the same variety of corn, (eight-rowed yellow,) grown on different soils, in Lewis county, (New York,) 1847.

The corn grown on a clay loam yielded 1.452 per cent. of ash; that raised on a sandy plain, with a top-dressing of manure, yielded 1.710 per cent. of ash; that grown on an intervale, without manure, 1.748 per cent.; and the proportions of potash, soda, lime, phosphoric acid, &c., vary considerably in the three analyses.

When the writer first read Boussingault's statement of the very small proportion of lime which is found in the ashes of the grain of Indian corn of Europe, (see Rural Economy: edition of Appleton & Co., 1845, p. 414,) he was persuaded that the corn of our rich limestone region would not exhibit the same deficiency in its ash; but the above analyses, as well as several by Emmons and Salisbury, Sprengel, and others, show that lime enters in very small proportion into the composition of the *mineral* portion of this grain. In which respect it resembles wheat, but contains still less lime than that grain, and differs widely from the tobacco plant, the ashes of which always contain much lime. Phosphates of magnesia and of the alkalies are found in the corn in much larger proportion than the phosphate of lime; and, like all the grains, the *phosphates* make up the greater proportion of the weight of the ash. The case is different in regard to the leaves, stems, husks, cob, &c., which

* Quoted from an article, by the writer, in the Kentucky Farmer.

generally contain a larger amount of potash, lime, soda, magnesia, &c., and a smaller proportion of phosphoric acid.

Some of the cobs from the corn, (No. 2 c,) grown in Fayette county, were incinerated, and the ash obtained submitted to analysis, with the following results:

COMPOSITION OF THE ASHES OF THE COB OF INDIAN CORN. IN 100 PARTS OF THE COB OF CORN, (NO. 2 c,) THOROUGHLY DRIED.

Potash	0.3588
Soda	.0065
Lime	.0024
Magnesia	.0355
Oxides of iron and manganese	not estimated
Phosphoric acid	.0274
Sulphuric acid	.0007
Chlorine	not estimated.
Silica	.1742
Carbonic acid and loss	.3655
Total ash in 100 parts of dried cob	0.9710

From the above analyses it will be easy for any one to calculate the quantity of essential mineral matters removed from an acre of land by a crop of corn, in the grain and cobs only. Thus, in the crop of seventy-five bushels, raised on Mr. Keiser's farm; as one hundred pounds of the dried corn gave more than one pound and four tenths of a pound (1.412) of ash, the whole seventy-five bushels, each of fifty-six pounds, weighing in all four thousand two hundred (4,200 lbs.) pounds of corn, would take more than fifty-nine pounds (59.304 lbs.) of essential mineral matters from the soil in the grain alone; and the *cobs*, calculating their weight as one fifth that of the corn, would rob it of more than eight pounds (8.156 lbs.) more of these valuable ingredients.

Many analyses have been made of the ashes of the various vegetable products of the farm and of the garden in Europe, and some in this country. For instance, a very full examination of the various parts of the Indian corn plant, at different stages of its growth, &c., as well as the analyses of several other grains, grasses, and garden and field vegetables, may be found detailed in the Reports of the Geological, Agricultural, &c., Survey of New York: (Natural History of New York, part Agriculture:) made by Emmons and Salisbury, and published by that State.

It is desirable that such examinations should be multiplied in this country; that the relationships of our various crops to the soil may be clearly ascertained.

In the above analyses of the Indian corn, the proportion of oil stated does not probably represent the whole contained in the grain; the examination was rather *comparative* than exhaustive; both specimens, ground alike, were digested for an equal time in equal quantities of ether, and the oil washed out by displacement. If the corn had been reduced to a finer powder, or brought to a pulp by boiling with water, before digesting it in ether, it is probable a somewhat larger quantity of oil would have been separated. For the corn contains quite a considerable quantity of yellow oil, to which it owes its great fattening property. Boussingault found from 7.8 to 9 per cent. of oil in corn. Poggiole found 6.7 per cent. Charles T. Jackson, (Patent Office Report, 1857, Agriculture,) from 2.9 to 4.2 per cent., and Polson 4.4 to 4.5 per cent. (*Liebig and Kopp's Jahresbericht fur* 1855, *p.* 889, *and* 1856, *p.* 809.)

See the end of this Appendix for a comparative table of the ashes of corn, wheat, tobacco, &c.

CHEMICAL EXAMINATION OF THE ASHES OF WHITE WHEAT, GROWN ON KENTUCKY SOIL, &c., &c.

The specimen of prime white wheat selected for the examination was obtained, March 23d, 1859, from Messrs. J. L. Elbert & Co., of Lexington; grown by Dr. Latham in that vicinity, on rich blue limestone land. It had been in the warehouse, where there was no fire, about six weeks—the weather having been rather warm for the season. Before incineration, experiments were made as to the relative amount of *moisture* it would give out on exposure at various temperatures; which resulted as follows, viz:

1. Exposed for thirty days to the dry air of the laboratory, daily heated by the furnace stove to the temperature of about 75° F., *it lost* 4.398 *per cent. in weight by the escape of moisture.*

2. Another quantity of the same wheat, kept in the water-bath, where it was exposed to boiling water heat, for two successive days, *lost in all* 12.710 *per cent. of moisture.*

3. A third quantity, heated for five hours in the oil-bath, to the temperature of 400° F., *lost as much as* 17.540 *per cent. of its weight.* The sample which had been dried in the water-bath was crisp, slightly deepened in color, and as though cooked; the gluten having been partly altered by the heat, so that the quantity of elastic paste which it would make with water was diminished.

That dried in the oil-bath, at 400° F., was completely parched and browned, and the germs, of such grains as had begun to sprout, were completely blackened, so that the loss of weight in this experiment was greater than that of mere *hygroscopic moisture.*

Air-dried, or dried at or below the boiling temperature, the wheat proved quite hygroscopic; giving up moisture and losing weight in a dry atmosphere, or when heated, and absorbing moisture and regaining weight when exposed to moist air, at a lower temperature.

There is probably a greater change in weight, in wheat, under these circumstances, than persons generally suppose. I have no doubt that wheat, taken from a moist "pen," and dried in a warm warehouse or mill, may lose from 4 to 6 per cent., by weight, of *moisture*, in a few days or weeks.

Some of this white wheat, thoroughly air-dried, was carefully reduced to ashes and these analyzed, with the following result:

COMPOSITION OF THE ASHES OF WHITE WHEAT.

	In 100 parts.	In a bushel.
Potash	0.454	0.2724 lbs.
Soda	.011	.0066 lbs.
Lime	.136	.0816 lbs.
Magnesia	.202	.1212 lbs.
Oxides of iron and manganese	traces.	traces.
Phosphoric acid	.760	.4560 lbs.
Sulphuric acid	.007	.0042 lbs.
Chlorine	.029	.0174 lbs.
Silica	.034	.0204 lbs.
Carbonic acid and loss	.081	.0486 lbs.
Total ash	1.714	1.0284 lbs.
Proportion of phosphate of lime	0.246	0.1473 lbs.
Proportion of phosphate of magnesia	0.562	0.3372 lbs.
Proportion of phosphoric acid in the alkaline phosphates	0.295	0.1776 lbs.

It will be seen that the ash of wheat is quite rich in phosphates, especially phosphates of magnesia and lime, taking more of these from the soil than the Indian corn, in equal weights of the grains; and we can readily understand how even a rich soil may, after successive wheat crops, refuse to produce it in a healthy and profitable manner, because of the resulting deficiency of phosphates in the soil; and why the English farmers find it so advantageous to employ bone-dust, or super-phos-

phates on their wheat lands, that they actually import bones from distant foreign countries, and even glean the battle-fields of their ghastly relics.

To give a comparative view of the amount of the various *essential mineral elements of the soil,* which is removed *from an acre of ground,* in a crop of wheat, corn, tobacco, or wine, I append the following table. In which I estimate only the grain of the corn and wheat, without the stalks, leaves, husks, cobs, &c., and only the pure fermented wine; supposing the leaves and cuttings of the vine and the lees of the wine, deposited during and after fermentation, to be returned to the soil.

TABLE SHOWING THE MINERAL MATTERS REMOVED FROM THE SOIL.

	In a wheat crop of 20 bushels.	In a corn crop of 50 bushels.	In a tobacco crop of 1000 lbs. and stalks.	In 500 gallons of Catawba wine.
Potash	5.45 lbs.	8.06 lbs.	69.73 lbs.	1.428 lbs.
Soda	.13 lbs.	6.22 lbs.	6.80 lbs.	.640 lbs.
Lime	1.63 lbs.	.22 lbs.	68.00 lbs.	.180 lbs.
Magnesia	2.43 lbs.	3.61 lbs.	8.67 lbs.	.468 lbs.
Phosphoric acid	9.12 lbs.	11.85 lbs.	8.13 lbs.	.380 lbs.
Sulphuric acid	.08 lbs.	not estimated.	8.40 lbs.	.876 lbs.
Chlorine	.35 lbs.	not estimated.	1.06 lbs.	.012 lbs.
Soluble silica	.41 lbs.	.71 lbs.	5.86 lbs.	.084 lbs.
Total mineral matters from an acre of land	19.60 lbs.	30.67 lbs.	176.65 lbs.	4.068 lbs.

This table clearly exhibits the relative exhausting influence of these several crops. It will be seen that the tobacco consumes the most, of all the essential ingredients of the soil, but especially of potash and lime. The wheat and corn crops require *phosphates* in larger quantity than any other materials; and the quantity taken in the wine appears remarkably small. It is to be recollected, however, that all *hoed crops* cause a much greater deterioration in a given time than those which bind and cover the soil during their growth, as the small grains, clover, &c.; more of the soluble materials being decomposed and washed out by the atmospheric agents in the latter case than in the former.

OBITUARY NOTICE

OF THE

LATE PRINCIPAL GEOLOGIST OF KENTUCKY,

DAVID DALE OWEN, M. D.

The decease of our late distinguished chief in the Geological Survey of Kentucky, which occurred in the afternoon of November 13th, 1860, at his residence in New Harmony, Indiana, at the age of 53, will be deeply deplored throughout the wide circle, in this country and in Europe, in which he had, by his great industry and eminent services in the field of exploration of American Geology, deservedly acquired a reputation as elevated as it is extensive.

Dr. Owen was born June 24th, 1807, at Braxfield House, Lanarkshire, Scotland; and surrounded by the picturesque scenery of that locality, and witness of the stirring events connected with the great social experiment of his father, Robert Owen, the distinguished philanthropist and large mill owner, whose efforts were directed to ameliorating the condition of the laboring classes, Dr. Owen was early led to admire the works of nature and taught to examine and think for himself; inducing habits of self-reliance, which he retained throughout life.

On leaving home, with a younger brother, to receive instruction in the celebrated educational establishment of Emanuel Fellenberg, at Hofwyl, Switzerland, their father's parting advice was to devote a large share of attention to the science of chemistry, so practically useful in its bearings on the other branches of science as well as on the arts and manufactures. This judicious advice was faithfully followed at this institution, during the years 1824–5–6, as well as afterwards under the distinguished Dr. Andrew Ure, in Glasgow, in 1827, and subsequently with Dr. Turner, in London, whilst on a visit of two years made after his removal to America.

In the fall of 1827 Dr. Owen accompanied his father to this country, settling in New Harmony; of which town the latter had purchased a large part, for testing his philanthropic and educational plans. Dr. O. landed in New Orleans January, 1828, and with the exception of some time spent in Paris, France, to improve himself in drawing, for which he had considerable talent, as exhibited in the numerous sketches in his various Geological Reports, and the courses of lectures on chemistry and geology in London, the remainder of his life was spent in this region, devoted to study and to practical geological and chemical pursuits connected with the development of our mineral and agricultural resources in the western, northwestern, and southwestern States.

In 1833 he was associated, as a volunteer explorer, with the late Dr. Gerard Troost, then engaged on a geological reconnoissance of Tennessee; and, after two years assiduous devotion to medical studies, received the degree of Doctor of Medicine from the Ohio Medical College, Cincinnati, O., in 1835. In 1837 he married Miss Catherine Neef, daughter of Joseph Neef, the former associate of Pestalozzi in

Switzerland, and later in New Harmony with that distinguished early promoter of American geology, Mr. William Maclue, a considerable portion of whose geological and mineralogical collections form the basis of the truly immense cabinet which has been accumulated by Dr. Owen during his active life, by purchases, exchanges, and in his numerous geological explorations. A collection which is itself a vast monument to his industry and zeal in the pursuit of science, and which, recently offered by his executors to the State of Indiana, it is hoped will be purchased by that Commonwealth to be preserved entire for the purposes of future reference and instruction, in accordance with the feelings of the late owner.

In 1837 Dr. Owen was appointed Geologist of Indiana, and began his active life as an independent explorer in the extensive field of American geology and mineralogy by a general reconnoissance of Indiana; the report of which formed a small octavo volume, which was reprinted by the Legislature in 1859, when he was again appointed Chief Geologist of that State, under the auspices of the State Agricultural Society, and with the active co-operation of his brother, Col. Richard Owen, who has recently been appointed his successor as State Geologist, and who, by agreement, was to perform the field work. With this assistance, and the co-operation of others in the field and in the laboratory, the Geologico-Agricultural Survey was carried over a considerable portion of the State; the report of which, constituting a very valuable contribution to geological and agricultural science, is now passing through the press at Indianapolis, under the charge of his brother and successor in the survey.

On the 31st of July, 1839, Dr. Owen was appointed by the General Government to explore the mineral lands of Iowa, Wisconsin, and Illinois, and required to complete the

survey before winter set in. The notification of his appointment and his instructions reached him in New Harmony August 17th following, yet, by the exertion of unusual energy, and by the aid of one hundred and thirty-nine sub-agents and servants, whom he had employed in an incredibly short space of time, provided with tents, provisions, chemical tests, &c., &c., and organized into twenty-four working corps, each furnished with skeleton maps of the townships assigned them —each to examine thirty quarter sections daily, and report to him at appointed stations—he was enabled to make a satisfactory exploration, in every quarter section, of about eleven thousand square miles of territory, mostly wild and uncultivated, within the limited time allotted, and to forward his report to the Land Office in the month of January following. During the course of this almost incredible labor he crossed the district under examination, in an oblique direction, eleven several times. The report of this survey, published in the documents of the 1st session of 28th Congress, with its accompanying diagrams, maps, and plates from beautiful sketches of scenery by his own pencil, forms an enduring memorial of his great executive abilities and untiring zeal and industry.

During the years 1847–8–9–50, again under the appointment of the General Government, he, with his several corps, surveyed, in Wisconsin, Iowa, Minnesota, and part of Nebraska Territory, an extent of country in area exceeding two hundred thousand square miles, or four times greater than the State of New York. The report of this survey, published by Congress in 1852, forms a very large and elegant quarto volume, containing more than 600 pages of text, and numerous wood cuts, maps, diagrams, and other engravings; amongst which are some of fossils which were medal-ruled on

steel, a process never before applied to the illustration of organic remains. Another report by him, of his survey of the Chippewa Land District of Wisconsin, was published by the General Government in 1849–50.

Early in 1854 Dr. Owen, as Principal Geologist, began the Geological Survey of Kentucky, of which he personally made a complete general reconnoissance, and to which he devoted most of his attention up to the time of the commencement of his labors in Arkansas. His "General Report," which forms the beginning of this volume, is his last contribution to this work, and was written whilst suffering under general ill health which preceded his dissolution.

Appointed, in April, 1857, State Geologist of Arkansas, he commenced in October of that year, as soon as his engagement in Kentucky was ended, under the then existing appropriation, a general reconnoissance of Arkansas, which he carried on successfully up to the time of his death. His last efforts, in that way, even after disease had so far mastered his corporeal frame as to render necessary the aid of an amanuensis, were in the daily dictation, *up to three days only before his death*, of the second volume of his Report on the Geology of that State. His first "Report of a General Reconnoissance of the Northern Counties of Arkansas," a handsome octavo volume, with plates from his own drawings, was published at Little Rock, Arkansas, in 1858; and the second volume, to the completion of which he devoted his dying energies, is now passing through the press under the supervision of his brother, Col. Richard Owen.

During the last two years of the prosecution of the Geological Survey in Kentucky, the practical labor, in the field and in the laboratory, was carried on by Messrs. Lyon, Lesley, Lesquereux, and Peter, under the immediate direction of

Dr. Owen. He, by the terms of his continuance in the office of Principal Geologist of Kentucky, being allowed to devote a considerable portion of his time to the *General Reconnoissance* of Arkansas; that of Kentucky having been completed by him, and the condition of the survey and the experience of his assistants in that State being such that it was no longer necessary for him to devote to it his exclusive personal attention.

In addition to these labors, under public patronage, Dr. Owen made many geological explorations for individuals and corporations, and contributed by his pen to various scientific journals and other periodicals. His wide-spread reputation, in this country and in Europe, secured him an extensive correspondence; and whilst it brought him into reciprocal intercourse with such men as Murchison, Lyell, Mantell, Verneuill, and others, and kept up agreeable associations with the leading scientific minds of this country, levied a heavy tax upon his time and industry. Often the claims for rest, absolutely requisite to the daily recuperation of his over-wrought powers, were set aside for the pleasures of science or the calls of duty or of friendship; and the light in his laboratory, shining far into the "small hours" of the night, might indicate to his solicitous friends the too rapid consumption by him of that taper of life which he so freely sacrificed to his favorite and engrossing pursuits.

The disease, which was the immediate cause of the death of Dr. Owen, was rheumatism, determining finally to the heart, and induced, doubtless, by his severe labors and exposure in his field explorations.

The bent of Dr. Owen's mind was decidedly to *practical* results. Hence his great fondness for the applications of chemical research to the purposes of every-day life. Hence

his efforts to discover the cause of milk-sickness, and his great desire to develop and improve agriculture in this country. To the eminently useful information conveyed to the enlightened farmer by accurate soil analyses he always devoted special attention, and we are gratified to state that the practical results thus obtained have been extensively and repeatedly acknowledged. We learn that, besides the valuable articles on agriculture which he contributed to the several volumes of these reports, he had also partly written out some important suggestions on the best means of preserving the fertility of the soil unimpaired.

The labors of our lamented friend were peaceful and unpretending, but they will connect his name forever with the history of science at large and the improvement of this country in particular. For whilst the political storms which periodically sweep over the country may leave no other remembrances but of confusion and disaster, the quiet record of the discoveries of the man of science yield a perennial harvest of beneficial application.

As a man Dr. Owen was modest and undemonstrative, yet firm, independent, and self-reliant. A gentleman of the strictest honor, and of the most child-like honesty in his dealings with the world. Wholly absorbed in his much loved science, his money, his time, even his life, were freely and exclusively spent in its pursuit. Unselfish and ever careful to give every one his due on all occasions, he always awarded to all his various associates, in his reports of his numerous explorations, their just share of honor and responsibility.

The loss which is sustained in his death is very great. In the language of an obituary notice of him in Silliman's American Journal of Science, "In view of his great executive and scientific abilities, rich experience, and comparative

age, science had much to hope for in the continued life of Dr. Owen, and his loss is great in proportion to these hopes."

The monument which he was erecting to his genius and labors, in the four volumes of the Reports of the Geological Survey of Kentucky, is left incomplete; first, by the failure of the last General Assembly to appropriate funds for the continuance of the survey, and secondly, by his decease; but the work thus commenced by him, and so ably carried on by the aid of a liberal policy, will not certainly be suffered to lose a great part of its utility by being arrested before reaching the point most favorable for practical application. Its completion at an early day is at once necessary to the full development of the immense mineral and agricultural resources of the State, as it would be gratifying to the numerous friends of the deceased and to the world of science in general. Kentucky will yet redeem, to her intelligent citizens and to the civilized world, the pledges she gave in the commencement of our great Geological and Agricultural Survey; and the results of the latest labors of our lamented associate will be crowned, by completion, a perennial monument of her enterprise and liberality in the advancement of improvement, a land-mark in the world of science, and a sacred depository of the honored name of her late distinguished Chief Geologist.

REPORT

OF THE

FOSSIL FLORA,

AND OF THE

STRATIGRAPHICAL DISTRIBUTION OF THE COAL

IN THE

KENTUCKY COAL FIELDS,

BY

LEO LESQUEREUX, Palæontological Assistant.

INTRODUCTORY LETTER.

COLUMBUS, O., January 31st, 1860.

D. D. Owen, M. D.:

DEAR SIR: According to your instructions, I spent the months of May and June, 1858, in a detailed exploration of the coal fields of Union, Crittenden, Hopkins, Christian, Muhlenburg, Ohio, Daviess, and Henderson counties, of which I had, the previous year, made only a short reconnoissance. The months of August and part of September, of the same year, were employed in surveying the distribution of the coal strata of Bath, Montgomery, Powell, Morgan, Owsley, and Breathitt counties. In the first of these explorations I was accompanied by Mr. Alfred Owen; in the second by Major T. C. Downie. To both these gentlemen I wish to express my gratitude for kind and valuable assistance. Continuing the explorations of the eastern coal fields, during the month of May and part of June, 1859, I surveyed Greenup, Carter, Lawrence, Johnson, and Floyd counties. But owing to the sudden sickness of Mr. Alfred Owen, my assistant, I had to perform the greatest part of the work alone. The difficulty of the task would have been severe but for the assistance and hospitality which I received everywhere from the inhabitants, who generally manifested the greatest interest in the survey. It is the result of those different explorations that I take the liberty to present to you, sincerely desiring that it may meet your approbation.

Since the publication of my former report, the final report of the Geological Survey of Pennsylvania has appeared, contrary to general expectation. In this work, I am accused by Prof. H. D. Rogers, formerly director of the Geological State Survey of Pennsylvania, of plagiarism, or of a breach of literary obligation, for the quotation of half a page of my own report, delivered to him in 1854, and of the disposal of which I had since been left entirely ignorant. It is evident that no general

conclusion can be drawn from palæontological researches, except from a comparison of the distribution of the fossil plants in the coal strata of many and far distant localities. To prevent a geologist from making such comparisons, by denying him the use of his own observations, till a publication, though indefinitely postponed, of his report, is made, is truly the same as depriving a workman of his tools. I was thus forced to recall a few of the observations made by myself years ago, in Pennsylvania; and as I was careful to mention the source of the quotation and the right of property of the Pennsylvania survey, the accusation of Prof. H. D. Rogers will appear to every impartial mind as unjust as unaccountable.

Very respectfully yours,

LEO LESQUEREUX.

INTRODUCTORY REMARKS.

My first palæontological explorations in Kentucky were made in too short a time, and extended over too large an area of country, to give at once satisfactory and reliable results. They embraced a general reconnoissance of the western coal fields of Kentucky; therefore, my first report gave only a very general survey of the western coal measures, to be completed by subsequent and more detailed researches. Even now, it is not to be supposed that this report will satisfy the expectations of every coal proprietor. Although prepared to mark the geological horizon of most of the beds of coal which I had an opportunity of surveying, there are still many out-crops, even open coal beds, which could not come under my examination; either for want of time to visit them, or because the beds being still unopened, the characters of the shales and fossils could not be ascertained.

There is, indeed, a great difficulty attending the application of palæontology to the identification of the coal strata. The fossil plants being, of course, unequally and irregularly distributed in the shales of the coal beds, and the shales themselves being sometimes entirely wanting, obscure out-crops of coal can scarcely be studied, and, therefore, cannot be placed with accuracy, when they are not exposed by a good entry.

This deficiency in the application of palæontology to the determination of geological levels of the coal, induced me to extend somewhat the range of my explorations, and to examine and report the stratigraphical distribution of the coal as often as it was possible to do so with advantage. I have always endeavored, first, to determine the position of each coal bed by the fossil plants of the shales; and afterwards, even if the examination gave entire satisfaction, I have made, when it was possible, a section either of the coal itself, with the adjoining strata, or of the measures exposed in its connection.

In reporting a number of these sections, I may possibly have to go over a few that have already been published; but this reviewing of sections, even if it should be of frequent occurrence, will still become useful for the following reasons:

First. The explorations of the coal strata form now a distinct part of the geological survey. It would, therefore, be advantageous to reconsider the different data which have been collected and present them all together.

Secondly. The reliability of palæontological evidence has been, and may still be, often disputed. It is therefore necessary to prove its correctness by comparative sections, made in different localities. This comparison cannot always be established upon unpublished sections only.

Thirdly. Good, comparative lithological sections, of actual superposition, combined with palæontological evidence, afford the only means of ascertaining the relation of the strata in the different coal fields of Kentucky and of America. The identity of the fossil plants of a bed of coal, more or less distant from another, offers at once evidence of horizontal equivalence, and affords easy means of comparing entire sections. All the sections published without this fixed point as a basis of a common geological horizon, may be interesting for some particular locality, but are more or less uncertain, and often useless, in a general examination of the coal measures. Moreover, these comparative sections furnish the best indications to direct the researches for coal in the intervening localities.

The plan of this report is, therefore, easily traced; it is first necessary to review the general character, either palæontological or stratigraphical, of each bed of coal, and to establish the value of these characters by some local sections. This mode of examination may be somewhat tedious, but it will afford solid materials for the true history of our coal formations.

I shall then make a general section of each county which I have surveyed, pointing out all the beds of coal examined, and their relative position in the section.

A comparison of the distribution of the coal strata, in both the western and eastern basins of Kentucky, must necessarily follow, and must be extended as far as possible over the coal measures of Ohio, Pennsylvania, etc.

I deeply regret that I was unable to extend my explorations over the

entire coal fields of Kentucky; but the time, as yet, has been too limited for such a work, and therefore much remains still to be done for a full description of the Kentucky coal measures. According to the directions of the State Geologist, I have examined the richest parts of the coal fields, especially those which are easy of access, and the more likely to attract the attention of the miner and the capitalist.

NATURAL DIVISION OF THE COAL MEASURES.

If I had to report on the western coal fields of Kentucky only, I should have little or nothing to communicate on any beds of coal under the conglomerate. But the exploration of the eastern coal basin has shown that the true coal measures begin there immediately above the sub-carboniferous limestone, or, when this limestone is absent, the coal succeeds immediately to the sub-carboniferous knob sandstone, or the upper division of the Chemung group. As some beds of these inferior strata of coal are of workable thickness and of excellent quality, it becomes of the first importance that their position should be described, and their characters, as far as they are determined, made known.

The coal measures below the conglomerates have been generally distinguished by a peculiar name from the measures above; they have been called false coal measures, proto-carboniferous formations, &c. I see no good reason for this distinction. If it is based on the fact that the inferior coal beds are not generally found over the whole extent of the coal fields of America, the same can be said of the coal strata between the Mahoning and the Anvil Rock Sandstone, and particularly of the upper coal measures above the Anvil Rock. If this separation is made, from the thickness and extent of the great deposit of sandstone named *conglomerate*, or from its composition of coarser and more pebbly materials, the same reason for a further separation of the coal measures might be found in the thickness, extent, and composition of the Mahoning, and even of the Anvil Rock Sandstones. A separation of the inferior coal beds from the higher measures associated with them, could only be authorized by a difference in the vegetation of which the coal has been formed, and consequently in the species of plants found in the shales. But this difference does not exist, as we shall see presently. It is, therefore, more rational to take the coal measures in their whole vertical extent,

as a single and inseparable formation, dividing them, for the sake of a better understanding, in four different parts.

1. The coal measures below the conglomerate.

2. The measures between the conglomerate and the Mahoning sandstone.

3. Those between this last sandstone and the Anvil Rock.

4. The upper coal measures above it, with their top still undetermined.

COAL MEASURES BELOW THE CONGLOMERATE.—GENERAL DISTRIBUTION.

They appear in the western coal fields of Kentucky—

1st. Near Caseyville, in Crittenden county, in a stratum of black shales containing a thin coal. This shale is well exposed at a short distance from Bell's mine, on the bank of the creek.

2d. In Breckinridge and Meade counties, where two beds of thin coal have been observed in the thick strata of sub-carboniferous limestone,* they have not yet exposed a workable bed.

In the eastern coal fields, those low measures are much better developed, and exposed nearly all along the western edges of the basin. I examined the first outcrops of their coal near Jas. Wills', in Montgomery county; then between Slate and Beaver creeks, on the road to McCormick's, as also just above Mr. McCormick's house, on the road to Hazlegreen, and a few miles south of the head waters of Emmet's fork of Indian creek.

The most northerly outcrops of these coals which I visited, was at Clear creek, in Bath county, and the farthest southward at L. Bush's, on Walker creek, Owsley county, on the road between Proctor and Hazlegreen.

South of Owsley county, or even in this county, the inferior coal measures appear to thicken considerably in some places. Near Proctor, and in Pulaski and Rockcastle counties, they contain three to five beds of coal, one of which is worked four to five feet in thickness.† Above the shales of the Cumberland river, in Wayne and Clinton counties, Mr. Jas. Lesley, jr. reports two, and sometimes three beds of coal, below the conglomerate. In Northern Tennessee, near the limits of Kentucky, Prof. J. M. Safford has observed five (5) veins of coal in the same

* My first Report, diagram 4th and section, vol. 2, p. 89.
†Report 1st, diagram 4th, p. 233–237.

situation, one of which attains, in some pot holes, a thickness of five feet. In Virginia, south of the Kanawha Salines, Dr. S. H. Salisbury has seen five (5) beds of coal below the conglomerate, one of which is formed of alternate layers of slate and coal six to seven feet thick. The sub-conglomeratic coal has been observed, also, by boring salt in the interior of the coal measures. The section of Warfield, on Tug river, will show its position.

It is a remarkable fact that this lower coal has never been seen along the western edge of the coal measures of Ohio, where in many places the conglomerate attains to a great thicknes, when on the contrary, the sub-conglomeratic coal appears to be developed in Mercer and McKean counties of Northern Pennsylvania.

PALÆONTOLOGY OF THE LOWEST COAL MEASURES.

As far as has been ascertained, the palæontology of the coal beds below the conglomerate is very uniform. I have only found in the shales covering them the leaves, the cones or catkins, and the bark of different species of *Lepidodendron*. Judging from analogy, I suppose that this peculiar flora of the low coal will be found generally of the same nature in the whole extent of the measures below the conglomerate, with the exception of a few particular species to each different bed of coal; but this supposition wants to be sustained by sufficient palæontological evidence.*

At S. Wills' coal, the shales intermediate to the two beds of coal are entirely covered with the leaves of *Lepidodendron*. These leaves (*plate* 3, *fig.* 2) are easily known by their resemblance to long and narrow blades of grass. Although the appearance and nature of these shales is very different in two exposures of the same coal, being at one place hard, black, and fissile, when at a few yards distance they are replaced by a kind of yellow, soft clay, these leaves of *Lepidodendron* are found in the same abundance in both.

On the head waters of Emmet's fork, the bed of coal worked by Mr. McCormick is 75 feet below the conglomerate, and apparently on a lower level than the former, yet the shales covering the coal contain only leaves of *Lepidodendron*, with a few cones of the same tree, (*Lepidos-*

* Since writing this, I have had opportunity to survey the sub-conglomeratic coal measures of Western Arkansas, and found their flora characterized by some peculiar species, but rich and varied, indeed. *Neuropteris flexuosa* and *Flabellaria borassifolia* are as abundant in the shales below the conglomerate as above.

trobi.) The lower part of the coal, which is soft and slaty, (brash coal,) contains, besides the stems of *Lepidodendron*, a few prints of *Calamites*. The coal itself, which is of a very black, hard, and beautiful appearance, is mostly covered, in its horizontal sections, by thin layers of charcoal, marked especially with prints of small branches of *Lepidodendron.*

On Clear creek, in Bath county, the shales covering the coal are also marked by leaves and the bark of the same species.

By its fossil plants, the coal worked at Proctor might be referred to the same sub-conglomeratic series. Unhappily, I could not carefully examine it, being there prostrated by sickness. Mr. Downie, my able and efficient assistant, found in the shales of McGuire's coal, a piece of bark of a *Lepidodendron*, and some *Lingula*, with a *Flabellaria.* These two last species are generally characteristic of a higher coal; but such isolated specimens are not sufficient for conclusive evidence. The *Lingula umbonata* appears to have a wider range than was first supposed; and the *Flabellaria,* although more abundant in the No. 1 B. coal above the conglomerate, is a plant of the sub-conglomerate coal also.

These remarks on the characters of the sub-conglomeratic coal flora are confirmed by the observations of Mr. J. Lesley, jr., who, from his camp in Pulaski county, writes that he has only found, in the shales below the conglomerate, these leaves of *Lepidodendron*, with some prints which, from his sketch, evidently belong to scales of the cones of *Lepidodendron*, viz.: to the genus *Lepidophyllum*, of which two species have been figured in my former report. (*Pl.* 7, *fig.* 7 *and* 8, *vol. III, Geol. Survey of Ky.*)

In a catalogue of the fossil plants of America, published by the Scientific Association of Pottsville, I have described and figured a new species of *Pecopteris*, (*Pecopteris Sheafferi*,) found in McKean county by my friend, Prof. P. W. Sheaffer, of Pottsville. The coal in the shales, of which this species was found, is said to belong to the sub-conglomeratic measures. Except this plant, the shales which bear it do not show any other remains but leaves and fruits of Lepidodendron.

The specimens of shales collected in the Geological Survey of Arkansas, under the direction of Dr. D. D. Owen, and which were submitted to me for examination, are mostly covered with the same leaves above mentioned. There is besides part of the frond of a fern related to *Alethopteris nervosa*, but specifically different. Dr. Owen remarks, on

the Spadra coal, which, like all the other coals of Arkansas, belongs to the sub-conglomeratic series, that *some obscure stems, and long slender leaves or glumes, of some plants can be discovered by splitting up the shales.** These long slender leaves are the leaves of the *Lepidodendron*, and this observation confirms what I have before said about the general appearance of the flora. Mr. E. T. Cox, Assistant Geologist in the same survey, speaks of the coal strata in Crawford and Johnson counties, Arkansas, as containing in their shales mostly *Lepidodendron*, with *Sphenopteris*, *Calamites*, and *Pinnularia*.† I have seen no specimens of these last genera of plants in the shales examined, and do not know whether there are any new species among them. These remarks of Mr. Cox, who is very particular and careful in observations, tend to show that the different beds of the lowest coal measures must be characterized by some peculiar species.‡

I may mention here this curious coincidence. In the shales of the low coal of North Carolina, of which some beds are intercalated in the old red sandstone below the conglomerate, my friend Mr. J. P. Lesley found specimens of a *Lepidodendron* which I had never seen, except in the red shales below the conglomerate at Mauch Chunk and Pottsville, Pa.

STRATIGRAPHY OF THE SUB-CONGLOMERATIC COAL MEASURES.

The respective position of the coal beds below the conglomerate appears to be as variable as their horizontal distribution.

In the first report of the Geological Survey of Kentucky, Prof. D. D. Owen gives a section of 227 feet, in which the place of the highest coal is not fixed relatively to the conglomerate, but is shown to be 140 feet above the main coal of Proctor. On the same section are also marked two coal beds 4 and 6 inches thick, at 35 and 40 feet below the same main coal.

Three miles south of Jas. Wills', near the eastern limits of Montgomery county, a bed of coal 22 inches thick rests immediately upon a soft, buff-colored sub-carboniferous sandstone, containing, in great abundance, the shells of the Chemung group, and which, at this place, overlies another bed of sandstone, covered mostly with *Fucoides Cauda-Galli*. The coal is covered by 12 feet of black, soft shales, easily breaking,

* First Report Arkansas Survey, by D. D. Owen, p. 130.
† Ibid, p. 227-230.
‡ Vide note, p. 339.

marked by the fossil plants mentioned before, and containing pebbles of carbonate of iron. These pebbles are generally of the size of a common potato, having the same oblong form. From the top of these black shales to the base of the conglomerate sandstone, there is yet a covered space of 10 feet, which, according to the evidence of Mr. Wills, contains a streak of coal 4 to 6 inches thick.

In the hills just opposite the house of Mr. J. Wills, the formation containing *Fucoides Cauda-Galli*, about 100 feet thick, rests upon the lower sub-division of the Chemung group, and is surmounted by a conglomerate sandstone, containing here a great abundance of fossil shells, especially pieces of *Cyathophyllum*, *Cystyphyllum*, etc. In these hills there is no trace of coal or of limestone; but on the road to McCormick's, in crossing the hills between Slate and Beaver creeks, three miles east of Mr. Wills', the limestone makes its appearance with a stain of coal above it. In this part of the country, viz.: on the limits of Powell, Montgomery, and Morgan counties, the sub-carboniferous limestone is extremely variable, either entirely wanting, or appearing here and there in strata from 6 inches to 25 feet thick. Just above the house of Mr. McCormick, on the road to Hazlegreen, the limestone is seen succeeding the knob sandstone, first, as a thin layer of a few inches, cherty, perforated, coarse-grained, resembling a bastard limestone, then rapidly increasing in thickness to 15 feet, and becoming hard, fine-grained, and fossiliferous. It also supports here a bed of coal from 12 to 22 inches, capped by 5 to 6 feet of black shales, with the same plants as at Mr. Wills' coal. This coal, however, is too full of stems of *Lepidodendron*, and its quality is very inferior. The shales of this coal are overlaid by a ferruginous sandstone, probably a member of the conglomerate.

On the head waters of Emmet's fork of Indian creek, five miles south of McCormick's, the coal is 70 feet below the conglomerate, which forms picturesque bluffs of from 150 to 200 feet high. The bed measures 15 inches of hard, fine, bituminous, block coal, underlaid by 6 inches of shaly (brash) coal. The section is as follows:

	Feet.
Conglomerate	150
Shaly ferruginous sandstone	55
Black shales, with carbonate of iron	15
Hard coal	$1\frac{1}{3}$
Soft shaly coal	6 inches.
Fire clay to level of the creek.	

The coal, equivalent of the former, on Clifton bank, one mile south of

the road to Hazlegreen, is 22 inches thick. At Jas. Gibbles'; on the head waters of Brush fork of Beaver creek, it is reported of the same thickness; but I had no opportunity to examine it.

Although the distance between the coal and the conglomerate is much greater here than at Wills', I am satisfied that it is the same coal. Its characters and the nature of the shales are the same; and as for the measures below the conglomerate, we have already seen how variable they prove. The bed of ferruginous sandstone, which is here superposed on the shales, takes the place of conglomerate sandstone, or of millstone grit.

At the head waters of Clear creek, in Bath county, three miles above the furnace, a coal, the equivalent of the former, has been worked, about 35 feet below the conglomerate. It is cut in two by four feet of black shales, bearing the same characters as those intermediate to the two coals of Mr. Wills. Its base was covered with mud and water, and I could not see it well opened. It is reported by Prof. D. D. Owen, who also visited it, as being 1 foot and 10 inches in its upper member.

On Yocum creek, north fork of Licking, near the western limits of Morgan county, a coal 4 inches thick crops out just at the base of the conglomerate, without any shales above it; I consider it as the equivalent of the upper coal of Mr. Wills, but being like the following, at the level of the creek, the inferior strata were not exposed.

On the road from Proctor to Hazelgreen, on Walker creek, and on the property of L. Bush, there is a bed of coal 8 to 10 inches thick, which also crops out just at the base of the conglomerate, without intermediate shales. The hard sandstone covering of this coal contains two or three streaks of coal, one to two inches thick, running very irregularly. These irregular streaks of coal are often remarked above the coals immediately covered by sandstone, and are formed of detached parts of the woody matter of the coal, rolled and imbedded in the sand by waves or currents.*

It is purposely that I have until now delayed to speak of the Caseyville low coal, of which the true position has been subject to, and is still under discussion, among the geologists of the State Survey of Kentucky. The coal under consideration, said to be 18 inches thick, was struck in a

* A coal in the same position, just below the conglomerate, is reported by Dr. D. D. Owen, in the 1st volume of the Arkansas Survey.

well near the old distillery, above Caseyville, at a depth of 70 or 80 feet below Casey's coal bank, opened near by. When I visited the place in 1857, in company with Mr. E. T. Cox, on my first tour of exploration, I was shown only the shales of Mr. Casey's coal bank, and pronounced them the equivalent of those of Bell's and Casey's coal veins. Last year, having again visited the same place, with better information, I found under a heap of rubbish dug from the well, some shales of this low coal differing from those which cover Casey's and Bell's coal; they are soft, breaking irregularly, very black, marked with a few leaves of *Lepidodendron* only, and mixed with a great abundance of oval pebbles of carbonate of iron, like those mentioned in the black shales below the conglomerate elsewhere. In fact, the characters of the shales found near the mouth of the boring of Mr. Casey's well, compare exactly with those indicated in the description of the Wills and McCormick coal.

The presence of small pebbles of carbonate of iron in black shales, of which the palæontology is not distinctly marked, would, no doubt, have appeared unreliable and accidental, were it not supported by stratigraphical evidence. While I was investigating the question, in the vicinity of Bell's mine, Mr. Wheatcroft, the director of the mines, informed me that he had made many borings around Bell's vein, and had never found any coal below it, except a seven inch bed at a depth of 103 feet.*

To place the matter beyond question, he showed me, about half a mile from the entry of Bell's mine, in a small creek running into Tradewater river, a bank of shales, with a coal at its base, exposing the lower part of the measures, crossed in his different borings. The section is:

	Feet.
Fire clay and shaly sandstone under the Bell coal, extending downwards to top of the bluff, (covered space)	40
Hard, coarse sandstone in bank	16
Black shales, with pebbles of carbonate of iron	40
Coal, bituminous and soft	½
Hard, black fire clay	4
Yellow, shaly fire clay	1
Fossiliferous limestone, in bed of creek	1

Comparing this section with the place of the sub-conglomeratic coal of Owsley, Montgomery, and Bath counties, the analogy of distribution is striking, and when it is confirmed by palæontological evidence, and by the same mineral distribution, one can no longer question the identity

* No one is better acquainted with the geological strata of the country around Caseyville than this gentleman, who has been director of Bell's, Casey & Spigert's mines, and he asserts that, from topographical and stratigraphical evidence, these veins are all equivalent to the Casey coal opened above Caseyville.

of the coal, found below the Bell's and Casey's mines, with the coals of the sub-conglomeratic series.

It is true that the 16 feet sandstone above the black shales is but a thin substitute for the conglomerate; but near this western edge of the coal fields the conglomeratic appearance of the sandstone has nearly disappeared, and the thickness of the millstone grit is much reduced, and extremely variable. Opposite Caseyville, on the Illinois shore, where this millstone grit attains a good size, the distance from Dr. Long's coal, which is above the millstone grit, to the battery rock coal, acknowledged to be below it, is no more than 140 feet. In the vicinity of Mr. Wills', in Montgomery county, on the edge of the eastern coal fields, in a space of three miles, the difference in the thickness of the conglomerate is at some places, on the same line of strike, more than 100 feet.

As for the bed of limestone below the coal, it has been looked upon, by those who contradict the above opinion, as one of those thin strata of limestone which are said to occasionally run within the thickness of the millstone grit. But in that case, is the true millstone grit above or below this limestone? If below, we should have at this place the abnormal appearance of a limestone, which is not seen elsewhere. If above, we must certainly have above the limestone the sub-conglomeratic coal, equivalent to the coal 18 to 22 inches thick, resting immediately upon the limestone at McCormick's, and reduced to its true proportion by the gradual decreasing of the low coals towards the west.

A difficulty occurs in accounting for the position of a thin coal, which was seen in a boring by Mr. Sam'l Casey, 20 feet below his vein, worked near the Tradewater river, and which coal is said to be 20 inches thick. Unfortunately, when I visited the place the pit was entirely covered, and I could find around it no traces of any shales or of coal. It is possible that this coal might be a representative of our No. 1 A coal, generally placed at 25 feet below No. 1 B, and which has been developed here occasionally. If so, it would be the only place where it has been remarked in the whole extent of the western coal fields.

CONGLOMERATE.

Along the edge of the western coal fields, the millstone grit, a coarse sandstone, with or without pebbles, generally replaces the true conglomeratic formation. Its thickness does not appear to have been accurately measured. On the western edge, Mr. Lyon mentions it as being from

50 to 100 feet thick. The different members of the millstone grit occupy, probably, the whole space between the sub-carboniferous limestone and the lowest strata of what is generally called the base of the coal measures.

On the western edge of the eastern coal basin the formation is mostly conglomeratic. Still, often in part replaced by a coarse and ferruginous sandstone. Its thickness varies from 75 to 300 feet, attaining probably its highest point in Owsley county, where Mr. J. Lesley, jr. measures it at 300 feet, and at Rockcastle creek, where D. D. Owen found it to be 240 feet. Northward, viz.: in Greenup county, the conglomerate thins out considerably, and nearly disappears even; as by the measurements of Mr. L. Lyon, on Tigert's creek, six miles northwest of Grayson, the distance from the top of the millstone grit to the sub-carboniferous limestone is only 30 feet. These modifications are evidently local, and cannot be considered as resulting from any general law of distribution. From Greenup county northward, in following the western edges of the eastern coal fields, after crossing the Ohio above Portsmouth, the conglomerate again thickens to 300 feet, in Hocking valley, then thins out to a few feet in Licking county, near Newark, and thus it continues in undulations to its northern terminus, where, according to the measurements of Mr. Whittlesey,* it is from 100 to 150 feet thick.

From this, and what has been said about the unequal and local distribution of the coal below the conglomerate, it is evident that the sub-carboniferous measures were broken and much diversified in their general level by currents and other accidents, and that the super-position of the conglomerate was the true and firm basis for a uniformity of distribution, and consequently for the wide expanse of our coal fields.

Towards the eastern limits of the coal fields of America, the conglomerate attains its greatest thickness, and is generally divided in three or more members by shales, or thin strata of coal. The question, therefore, is, whether these beds of coal are not the equivalents of our western coal strata below the conglomerate, and consequently, whether the thickness of the measures contemporaneous with the deposit of the conglomerate, is not greater in the western coal fields than has been supposed. The conglomerate at Pottsville is about 1,400 feet thick; and although it becomes thinner towards the west, it may be that the McKean coal

* Second Report of Geol. Survey of Ohio, by W. W. Mather, pp. 57, 58.

measures, as well as those in Kentucky, counted as sub-conglomeratic, are true conglomeratic measures, or contemporaneous to the lowest conglomerate. The only difference would be that in some parts of East Pennsylvania they are pebbly and barren, while in others they are coal bearing, and without pebbles.

From the general views of the formation of the coal, as they have been presented in our former report, we must infer that the materials composing the conglomerate were brought and rounded by the wavy movements of the sea against the shore. Such movements cannot be uniform upon a very extensive area, therefore must the materials, carried by the waves, be deposited very irregularly. Supposing these movements to have been progressive for a long period of time, as the enormous quantity of heaped materials seems to warrant, large tracts of country must have been separated from the shores, in lagoons and marshes, and covered with the growth of the coal vegetation. Thus, while the sand and pebbles were heaped around them, they have formed isolated coal banks of various dimensions. A more general depression brought over the whole formation the upper and true conglomerate, generally extended over the whole coal fields of North America. In this case, the so-called sub-conglomeratic coal banks, either covered by sandstone or intercalated in the sub-carboniferous limestone, belong, with the limestone itself, to the true conglomeratic period.

These considerations are not without practical interest; they tend to demonstrate the fallacy of limiting the coal-bearing strata to the last conglomeratic formations, and of supposing that the appearance of coal below it, being something abnormal and a local phenomenon, without direct connection with the true carboniferous epoch, it would be useless to search for coal below its series. Although the prospect for good workable coal beds below the conglomerate, or within this formation, cannot be as promising as above it, researches for coal as far down as the knob sandstone, may be rewarded with satisfactory results in all the counties bordering the coal basin of Eastern Kentucky.

DISTRIBUTION OF THE COAL STRATA BETWEEN THE CONGLOMERATE AND THE MAHONING SANDSTONE.

It is very difficult to exhibit satisfactorily the distribution of the coal beds in this great division of the coal measures. The veins of coal which it contains, are all more or less subject to modifications, which alter their

appearance, even at short distances. They thicken or thin out; some separate or multiply; others, which are generally found separated by sandstone, limestone, or shales of various thickness, join and become united in a single bed of coal. Modifications of this nature occur in the whole extent of the coal measures, but nowhere are they more frequent and more marked than between the conglomerate and the Mahoning sandstone.

In the western coal basin of Kentucky, the first coal above the conglomerate is the same as the one designated No. 1 B, in the 3d volume of the report of the State Geological Survey. In the eastern coal fields, No. 1 A, with its characters and subdivisions, is generally present. Here we also find a third bed, properly, perhaps, a subdivision of No. 1 B, but distinct enough in Kentucky to be separately characterized. As we cannot change the nomenclature adopted in a former report, I shall have to number the coals as follows, omitting two thin streaks which sometimes appear in Ohio, but have not been seen in Kentucky:

Coal 1 *A*. Scarcely present in the western coal basin of Kentucky; generally developed in the eastern coal fields; and sometimes divided into two members.

Coal 1 *B*. The most reliable and most extensively developed, as well as the most variable of all the coal strata. Extensively worked in both basins of Kentucky, where it is generally the depository of cannel coal.

Coal 1 *C*. Might be called the coal below the limestone; generally a thin coal of no great value; placed at a short distance from the former, with which it often unites. It is for this reason, probably, that it was not mentioned in the reports of Ohio and Pennsylvania, and is likewise unnoticed by Mr. Lesley.

Coal 2. Scarcely known in the western coal fields of Kentucky; generally present in the eastern coal basin; bed of medium thickness, increasing considerably towards the southeast.

Coal 3 *A*. Good, reliable coal; often cannel, (like every bed of coal formed in connection with, or overlaid by a limestone,) of workable thickness, as well in the western as in the eastern basin.

Coal 4. Equivalent of the Pomeroy coal; placed at the base of the Mahoning or second conglomeratic sandstone, which forms the terminating mass upwards of this division.

The above subdivision may appear arbitrary, if considered in a mathematical point of view. Topography often takes into account outcrops of coal, without much regard to the peculiar arrangement of the coal strata; but in a general, correct, stratigraphical, and palæontological examination of the distribution of the coal strata, this method is not admissible. Some beds of coal, like our No. 1 B, for instance, exposed at one point as a single stratum, may be seen at a short distance, even on the same hill, to divide in two, three, or four beds of coal, separated by shales or sandstone of variable thickness. In a palæontological point of view, I could not but refer those accidental divisions to the parent bed, and regard them as in reality one bed of coal. Often as such cases have come under my consideration, I have reported them as mere subdivisions of one bed, noting the peculiarities of each member.

COAL 1 A. PALÆONTOLOGY, STRATIGRAPHY, AND DISTRIBUTION.

This vein, often divided into two members, presents itself with two different characters. Sometimes it is encased in a great bank (2 to 10 feet thick) of black, rusted shales, splitting parallel to the line of stratification, in large, thin laminæ. These are often barren of fossil plants; yet by close examination, I have never failed to find, in the interlaminated surface of the shales, cones of *Lepidodendron*,* and the *Lingula umbonata*; the only remains, with a few leaves of *Lepidodendron*, which these shales appear to contain. It is evident from this that the palæontology of coal 1 A is nearly related, if not quite identical, with that of the upper bed of coal, mentioned under the conglomerate. The only difference, indeed, appears in the scarcity of fossil remains in the shales of coal 1 A, and in the presence of *Lingula umbonata* in greater abundance. Independent of palæontology, there are some characters of the shales which help to the identification of coal 1 A: 1st. Their black, dull, rusty color. 2d. Their manner of splitting in large thin, regular slabs. 3d. The absence of small oval pebbles of carbonate of iron. It sometimes happens that the whole space separating this coal from the next above it, is occupied by black shales. In this case, when the distance is great, I have found in the slates, besides *Lingula umbonata*,† other species of fossil shells, especially a small *Leptæna*, and a fine new species of fern, and *Pecopteris velutina*, published

* Third volume of the Report of the Geological State Survey of Kentucky, pl. 7, fig. 3.
† Third vol. of the Report of Geol. State Survey of Ky, pl. 10, fig. 4

in the report of the Pennsylvania State Survey.* But these species do not appear as true characteristics of this coal, being only accidentally present. Nevertheless, I found the same species of shells at Yellow creek, Ohio, and at Johnstown, Pennsylvania, distributed in the same manner, and under the same geological circumstances.

The second division of this coal is far different from the former, in its palæontology and distinctive characters. The coal is generally covered by a coarse sandstone of variable thickness, containing numerous prints of a great many plants of the largest species. The genus *Lepidodendron* furnishes one half of these prints, after which *Sigillaria* (especially *Si. Brardii*) gives the greatest number, and then the *Calamites*. This sandstone is everywhere remarkable for the abundance of its fossil remains. It contains the great *Megalodendron* and *Megaphitum*, large trunks of trees completely transformed into sandstone; even a whole forest of calamites (mostly *C. Suckowii*) and *Sigillaria* is found at Carbondale, Pennsylvania, imbedded, and standing, in its coarse material.

The coal under this sandstone generally overlies a bed of brashy or slaty coal, splitting in thin laminæ, and bearing numerous prints of crushed plants of the same species as those enumerated above, with leaves of *Neuropteris hirsuta*.†

This vein of coal, in its two divisions, thins out and disappears westward. Even in the Eastern Kentucky basin it is never very thick. Its average is no more than two feet, and, except where it comes in contact with 1 B, it is never thicker than three feet. The coal is generally good, but under the black shales especially, it contains much sulphuret, and is somewhat caking.

Its two divisions, as indicated by the palæontological characters, are hardly ever developed together, the difference being rather local; but when they are so formed, the coal covered with sandstone is the upper division, and is separated from the lower by the black shales.

The modifications of this coal are well defined, and can be easily studied in Morgan and in Breathitt counties. On the head waters of Glady creek, branch of Red river, Morgan county, it makes its first appearance, and is worked 20 inches thick at the old Latham bank. It is there covered by one foot of black shales, with *Lingula*, and has above

* Vol. 2, p. 866, pl. 12, fig. 3.
† Report of the Geol. State Survey of Ky, vol. 3, pl. 6, fig. 4.

this a shaly sandstone, with iron ore. Its distance above the conglomerate is here about 50 feet.

At Jackson, Breathitt county, near the mines of Messrs. Jerry South & Son, this coal is seen about 8 inches thick, 20 feet below the main coal 1 B.

The following section is taken a few miles south of Jackson, near the mouth of Lick branch of Quicksand:

	Feet.	Inches
1. Gray micaceous shale, (gray metal,) and sandstone, space covered	20	-----
2. Bituminous coal	1	2
3. Black rusty shales, with *Lepidodendron* stems, and *Lingula*	9	-----
4. Coal, bituminous, tending to cannel	1	2
5. Black, hard, fire clay	2	4

Further up on the same creek, it has at the base 20 inches of coal, separated from a 6 inch bed above it by 4 feet 5 inches of black shales, with the same fossils.

The same vein near by, within 100 yards of Mr. Sam'l Back's house, on Quicksand creek, is not divided, and is 18 inches thick, covered by one foot of the black shales, with *Lingula* and *Lepidostrobi*. At this latter place the coal lies 25 feet lower than coal 1 B.

Divisions like those exemplified in these sections, are of less frequent occurrence in this coal than the change of its characters, viz.: the disappearance of the shales, to be replaced by sandstone, or *vice versa*. One and a half mile above the mouth of Barge fork of Troublesome river, Breathitt county, this bed has been worked under sandstone, and is 18 inches thick, bituminous, and somewhat shaly. Beyond the hill, on Tobacco branch of Charley's fork, the same vein is also 18 inches, but it is covered by 6 feet of rusty, black shales. At both places it has a clay parting. This bank can be traced across the hill by following its outcrop. Again, the same coal exposed above the mouth of South fork of Quicksand, is 16 inches thick, without clay parting, and is covered by 10 feet of its black shales, containing the characteristic fossils.

In Owsley county, No. 1 A coal is well exposed; along Jett's and Meadow creeks, one foot thick, covered by 10 to 14 feet of black shales, and in Morgan county, it crops out along Caney creek, near Judge Liken's house, where it is covered by its sandstone, and two miles below, where it has two feet of coal, overlaid by 8 feet of black shales, always with the same fossils.

In Greenup county, No. 1 A coal is rather covered with sandstone than shales. At Mr. Sam'l Bradshaw's, on Indian creek, it is three feet thick, including an eight inch clay parting, and is overlaid by black shales, while near Steam furnace, and at Caroline and Amanda furnace, etc., it is mostly overlaid by sandstone. In this county, the distance between No. 1 A and No. 1 B varies generally from 20 to 30 feet. In Johnson, Floyd, and Lawrence counties, the vein thickens somewhat, and the distance from No. 1 B becomes greater. At Paintsville, Johnson county, it is 60 feet, and the coal is here two to three feet thick, immediately overlaid by sandstone. In the thickest part of the coal measures at Warfield, on Tug river, Lawrence county, the coal worked is No. 1 A, and the distance to 1 B is about 70 feet. In Ohio and Pennsylvania there is no great difference in the distance between No. 1 A and No. 1 B. In Licking county, Ohio, near Flint ridge, it is only 40 feet. At Salineville, it is reduced to 35 feet. At Yellow creek the vein is divided in two members, separated by 20 feet of black shales, and its upper member is only at a distance of 20 feet from No. 1 B. At Johnstown, Penna., 60 feet of black shales, containing in abundance the fossils belonging to this coal, separate it from No. 1 B. And at Archibald, in the anthracite region of the same State, near the east edge of the coal measures, a section which I owe to Mr. Ed. Johns, the director of the coal mines, marks its place at 25 feet from the coal there worked, which, according to its character, is our No. 1 B.

This apparently shows a great uniformity in the general extension of this coal. Yet in the examination of No. 1 B, we will see No. 1 A coming sometimes in close proximity, or even uniting with it.

COAL 1 B. PALÆONTOLOGY.

More than one hundred species of fossil plants, of the coal measures of America, have been found in connection with this vein of coal. Its flora is thus much varied. It nevertheless has a peculiar aspect, which cannot but be easily recognized, when its examination is made with any care.

The top shales of this vein of coal present two different characters; they are either grayish, somewhat micaceous and ferruginous, of fine texture, perfectly well adapted to the preservation of the prints of fossil plants, or else black, soft, also somewhat micaceous, very hard, bituminous, and nearly without fossils. In the first case, the vein below the

shales is a bituminous coal; in the second it is mostly cannel. It is well to remark here that plants have been but indifferently preserved in the bituminous shales of the beds of cannel coal, (except accidentally in sulphuret of iron,) having probably been destroyed by the action of marine water. On the contrary, the marine shells are generally abundant. It is also well to observe, that sometimes the shales are not present above the coal, and then the coal is covered by laminated sandstone, or *gray metal.*

The only species of shells found in the black shales of coal 1 B is *Lingula umbonata*, but in such abundance that it sometimes entirely covers the shales. Besides this, the bituminous black shales have generally preserved the leaves and cones of *Lepidodendron*, and leaves of *Flabellaria Borassifolia.* (Pl. 3, fig. 2.) In this respect, the resemblance to the black slates of No. 1 A and No. 1 B is striking, and the identification would be difficult but for the great abundance of *Stigmaria* which the black slates of No. 1 B contain, and which are not found in those of No. 1 A. Indeed, the *Stigmaria ficoides** appears to have been the plant living especially on the marshes of the coal, while they were covered with water, and to have been an essential constituent of the cannel coal.

The plants which, by their presence in the gray shales of this vein, are characteristic of its geological position, may be presented in three divisions. The first embraces the species common to this and other veins of coal, and which become characteristic only by the great number of their specimens; the second are the species truly, or, at least, apparently peculiar to the vein, which have not been found elsewhere, but are too scarce to be remarked as true characteristics; the third, the few species appertaining to this coal only, and which are distributed in great abundance over the whole area of the coal basin, and consequently are true characteristics of this coal.

Among those of the first class, the most abundant, is certainly the *Lepidodendron.*† Fifteen species, at least, of this genus have been found in the shales of No. 1 B; of this number, more than one half belongs to it exclusively, a few of the more common species only ascending higher in the measures. The genus *Sigillaria* is also abundantly

* Vol. III of this Report, pl. VII, fig. 2.

† American species of this genus have been described and figured in the final Geological Report of the State Survey of Pennsylvania, vol. II, pages 873 to 875, plates XV and XVI.

represented by twelve species, some of which, *Sigillaria corrugata*, Lsqx.; (*pl.* 4, *fig.* 6;) *Sigillaria stellata*, Lsqx.; *S. Serlii*, Brgt.; *S. tessellata*, Brgt.; *S. Alverlaris*, Brgt.; *S. elongata*, Brgt.; *S. attenuata*, Lsqx.; *S. catenulata*, Brgt.; and especially *S. discoidea*, Brgt., do not appear to ascend any higher in the measures.* *Calamites* are also well represented in a number of species, yet without predominance. Then come some of the largest ferns of the coal: *Neuropteris hirsuta*, Brgt.; in the greatest abundance, sometimes apparently filling, by the superposition of its leaflets, the entire thickness of the shales; *Sphenopteris latifolia*, Brgt., which ascends higher; *Hymenophyllites Hildreti*, Lsqx., (pl. 2, fig. 5,) found also in the shales of No. 3; *Alethopteris nervosa*, Brgt.; and *Al. Serlii*, Gopp, (pl. 1, fig. 3,) of which the range of distribution extends out of this vein.

In the second class the most prominent of the species are all the species of *Odontopteris*, except *O. Schlothimii*, Brgt.; which, perhaps, ascends higher; *Cyclopteris flabellata*, Brgt.; *Whittleseya elegans*, Newb.; *Nepheoptoris orbicularis*, Brgt.; *Neuropteris Clarksoni*, Lsqx.; *N. rarinervis*, Bunb.; *N. vermiculata*, Lsqx.; (*pl.* 2, *fig.* 7;) *Sphenopteris glandulosa*, Lsqx.; *Sp. Newberii*, Lsqx.; *Sp. Lescurii*, Newb.; *Sp. squamosa*, Lsqx.; *Hymenophyllites furcatus*, Brgt.; *Hymenophyllites artemisiæfolia*, Brgt.; (*fig.* 2, *pl.* 6;) *Callipteris Sullivantii*, Lsqx.; *Pecopteris Sillimannii*, Brgt.,† and a new *Alethopteris Coxiana*, Lsqx.; (pl. 1, fig. 2.)

The third class contains fruits of different sizes, from the smallest grain, no larger than millet seeds, to nuttlets as large, and still larger, than almonds. These fruits generally abound in coal No. 1 B, and are found in nearly every one of its outcrops; in Union mines, of Livingston county, in Bell's, Hawesville, and Breckinridge mines of the western basin, as well as in all the localities where coal 1 B is seen in the eastern coal fields. What these fruits are, (two species are figured in vol. 3 of the Report, pl. 7, fig. 8 and 9, and another very remarkable, pl. 2, fig. 4,) to what species, or eventowh at genus of plants they belong, is still an unsolved problem of the coal vegetation. Some small seeds, inclosed in large cones, have been recently ascertained to be the fruits of *Sigillaria;* a few of the nuttlets of the coal are perhaps the fruits of *Flabellaria;*

* Ibid, vol. II, pages 871 to 873, plates XIII and XIV.

† Ibid, description of fossil plants of the coal measures of Pennsylvania, vol. 2, pages 847 to 878, with plates.

but this species, although very abundant in the No. 1 B coal, is also found in other veins above this, especially in the Pomeroy coal, yet the fruits are entirely wanting.* The number of these fruits is without proportion to the number of species to which they could belong. This shows that the vegetation of the coal is far from being known, and that it contained some genera, of which the remains, leaves, or stems, have been destroyed, or are not preserved in the shales. Some of these fruits of large size are inclosed in a kind of leathery pericarp, or husk, enlarging at the top like a three-cornered funnel, and appear to belong to some species of palm. But, except Flabellaria, there is no leaf in the coal which could be related to this family of plants. Some others, generally found flattened, have a heart-shaped form, and grew around the stems of *Asterophyllites* or branches of *Calamites* as tubercles, or perhaps true seed.

The second true characteristic species of No. 1 B, found everywhere in its shales, and never till now found out of it, is *Alethopteris Lonchitica*, Brgt., (Rep. 3, pl. 6, fig. 3,) a fern which bears a great likeness to our common brake. (*Pteris aquilina L.*) Besides these, I may mention as less frequent, however, *Lycopodites carifolius*, Lsqx., (pl. 4, fig. 5,) found in Union mines, Livingston county, and at the mouth of Horse branch, one half mile below Catlettsburg, Greenup county, at both the farthest ends of the Kentucky coal fields, and *Neuropteris vermiculata*, Lsqx., (pl. 2, fig. 9,) with distant, sharply marked, though fine veinlets, especially common in Eastern Kentucky, and *Hymenophyllites artemisiæfolia*, Brgt., (pl. 2, fig. 6.)

Resuming the palæontology of the No. 1 B coal in its essential characters, we find, first, that it contains everywhere in its shales the greatest number of fossil plants; second, that its remains belong to the largest species of trees and ferns; third, that it is the depository of the fruits, and some *Alethopteris* and *Hymenophyllites* not found elsewhere. It may also be remarked, that it is deficient in the species of the true *Pecopteris*, or has but few of them.

COAL 1 B. STRATIGRAPHY AND GENERAL DISTRIBUTION.

This vein is apparently extended without interruption, except accidental ones, over the whole coal fields of the United States. It is the

* I have recently examined, in Arkansas, thick black shales of sub-conglomeratic coal, entirely covered with leaves of this species, without any remains of fruits of any kind.

most reliable of all the coal strata, as it is usually the one of the greatest thickness. In the western coal fields it is generally undivided, and is the first above the conglomerate. In the eastern coal basin it begins to show its subdivisions, its variability of forms, its increasing size. It is in both the great depository of cannel coal. In the western coal basin it has generally a clay parting from one to six inches thick, and in the eastern, two or three which thicken, disappear, or change their nature, in the most unaccountable manner. Its average thickness in Kentucky is four to six feet. Taking under consideration the whole extent of the coal fields of America, we find this thickness varying from 6 inches to 20 feet, accidentally to 40 feet. This coal is nearly always found in close connection with No. 1 C coal, the next bed above it. Thus it can sometimes be said to be in three members, each one having its peculiar characters. The upper one is covered by sandstone, (rarely by limestone,) and has the fossil plants at its base, viz.: in the top shales of the middle coal. This middle member is generally covered by the gray shales, with the plants heretofore enumerated. The lower member is overlaid by a coarse sandstone, with plants, but sometimes there is no sandstone, and the plants characteristic of No. 1 A are found in a brashy coal at its bottom.

In the western coal basin of Kentucky it has everywhere preserved its normal appearance. The shales above are sometimes absent, but, as is the case at Bell's mine, they appear in some part of the mines, and, in their absence, the sandstone forming the top of the coal is full of remains of Stigmaria. At Caseyville, Hawesville, and Breckinridge, it has only the black shales, formed under marine influence, with an abundance of *Lingula*, and scarcely any plants but *Lepidodendron;* but at Union mines, Livingston county, as also in the vein opened by Dr. Long, opposite Caseyville, it has both kinds of shales in close proximity; the black shales, with the *Lingula*, and the gray ones, full of fruits and plants. Along the northern edges of the same basin this coal appears to be lost, or, at least, if it is anywhere below the coal which crops out along the margin, it has not yet been discovered.

In the eastern coal fields of Kentucky, especially in Greenup, Breathitt, and Morgan counties, the changes to which this coal is subject may sometimes be traced on the same exposure of rocks, and distinctly show

its extension. On a branch of Stillwater, five miles from Hazlegreen, Morgan county, the coal is exposed along the creek as follows:

	Feet.	Inches.
Top sandstone	4	------
Gray shales, with the lower part soft, full of beautiful specimens of plants	4	------
Coal, with four inch clay parting	1	2
Fire clay	4	------

At a short distance the same coal is just below the sandstone, and the shales at its base bear the plants of the gray shales, covering the coal of the former section. It is not that the coal has changed places, but that here the feather edges of two divisions of coal 1 B draw near each other, viz: the one just below the sandstone, and the lower one below the shales. The three divisions are seen together three miles above Jackson, Breathitt county, on the Kentucky river, on the property of Mr. Thos. Sewell, where the section is as follows:

	Feet.	Inches.
Hard sandstone	6	------
Bituminous coal	1	10
Fine clay, with Stigmaria	1	9
Bituminous coal	------	6
Black brittle shales, with the plants	1	7
Bituminous coal	------	7

On main left fork of Cane creek the coal is exposed in the following manner:

	Feet.	Inches.
Compact sandstone	10	------
Bituminous coal	2	------
Clay parting	1	6
Bituminous coal	------	6
Fire clay	1	6
Gray metal and shaly sandstone	8	------

And near by, up the same branch of the same creek, it is:

	Feet.	Inches.
Hard sandstone	6	------
Gray soft shales, with plants	20	------
Bituminous coal	1	------

At Clinton furnace, in Greenup county, this coal is 16 inches thick, covered either by the sandstone or by an eight inch bed of carbonate of iron, and at a short distance up the ravine it takes the following form:

	Feet.	Inches.
Sandstone and shales	10	------
Bituminous coal	1	------
Shale parting, with plants	1	------
Cannel coal	1	------

It is generally the lowest division of this coal which is changed into cannel coal, while the upper member, separated by shales, or shale parting, preserves its bituminous composition. Near Mordecai creek, in Morgan county, two sections of the same coal, on the property of J. Schoolfield, show this difference:

	Feet.	Inches.
Shaly sandstone, hardening at the upper part	6	------
Brashy coal, or shales with Stigmaria	------	10
Cannel coal	3	------

And on the other side of the hill:

	Feet.	Inches.
Hard sandstone shales	6	------
Bituminous coal	------	4
Black shales, with Stigmaria	2	------
Cannel coal	3	------

Near Chinch creek, two miles south of the old Fulton forge, in Greenup county, on the land of the Maysville Oil Company, the cannel coal is found in the upper bed:

	Feet.	Inches.
Dark shales, full of Stigmaria	1	------
Cannel coal, in block	4	4
Shales, with plants	------	10
Bituminous coal	------	3

And at the mines of the Ashland Oil Company, near Greenup furnace, the cannel coal is between two strata of bituminous coal:

	Feet.	Inches.
Shaly sandstone, space covered	15	------
Bituminous coal	1	------
Clay parting	------	4
Bituminous coal	------	4
Soft clay parting	------	4
Bastard cannel coal	------	10
Hard block cannel coal	3	6
Fire clay	------	6
Bituminous coal	1	------
Sandy or shaly fire clay	2	------

In its union with the limestone coal, or coal No. 1 C, along the railroad from Ashland to Grayson, same county, our coal No. 1 B presents some other modifications. In the cut behind the bridge of Williams creek, one mile south of the tunnel, it has:

	Feet.	Inches.
Shaly sandstone	6	------
Limestone ore	------	2
Shaly coal, full of stems, with oxide of iron (C. 1 C)	2	------
Fire clay	4	------
Soft shales, with plants	4	------
Bituminous coal (C. 1 B)	1	------
Clay parting (C. 1 B)	------	6
Cannel coal (C. 1 B)	------	4
Fire clay to the road.		

Three miles from Kilgore's, up Williams creek, the section is as follows:

	Feet.	Inches.
Black shales, with *Lingula* and other shells	15	------
Bituminous coal	------	6
Soft fire clay	1	6
Bastard or shaly cannel coal	1	------

On Louisa river, six miles below Louisa, and nearly opposite Gavet's mines, our No. 1 B is distributed thus:

	Feet.	Inches.
Base of covered sandstone, 50 feet above low water:		
Shales and gray metal	5	
Bituminous coal	1	6
Cannel coal, without parting		6
Clay parting		6
Bituminous coal		2
Fire clay and shales		
Gray coarse shales		
Bituminous coal		
Hard laminated fire clay		
Gray micaceous sandstone, with broken plants		
Soft gray shales	2	
Shaly cannel coal		9
Black shales and *Lepidodendron*		6
Bituminous coal	1	
Gray soft shales, with plants of coal 1 B	4	

In this case both 1 A and 1 B are united probably with coal No. 1 C, and we have thus more than 30 feet of measures occupied by four divisions of this coal and its shales.

At Peach Orchard, on Louisa river, and in the same county, No. 1 A and 1 B, in connection with No. 1 C above them, occupy 100 feet of measures, with five veins of coal from one to two feet in thickness; and at Paintsville, Johnson county, the main coal 1 B, worked at Mr. J. Wheeler's, is four feet thick, with a four inch clay parting, and is covered by its soft gray shales, full of the characteristic plants, while behind the same hill it is divided in three members, each separated by 10 feet of shales and sandstone.

If we continue to follow this coal in its geological distribution eastward, out of Kentucky, we find it gradually becoming thicker, and taking its greatest development in the anthracite basins of Pennsylvania, beyond the Allegheny mountains, where, by its divisions, and the thickness of its different members, it becomes truly a "*mammoth vein*," or, as it is generally termed there, the *big vein*.

At Nelsonville, Ohio, the greatest coal mining district of the Hocking valley, coals 1 A, 1 B, and 1 C, are superposed in the following order:

	Feet.	Inches.
Sandstone and shales	70	
No. 1 C. Bituminous coal	4	
Black shales	20	
No. 1 B. Bituminous coal	1	10
Cannel coal	1	8
Bituminous coal		6
Shales, with abundance of fruits	12	
Bituminous coal	6	
Fire clay and shales below	27	
No. 1 A. Bituminous coal	2	6
Sandstone		

The 12 feet black shales, separating the upper member of No. 1 B from the lower, is in some places reduced to a one foot, or even six inches, shale parting. The characters of No. 1 C and No. 1 A are well marked in each of these coals.

At Zanesville, Ohio, coal 1 B is said to be six feet thick, mostly cannel, in the bed of the river. I have only seen its top shales, and thus ascertained its identity. At Salineville, Ohio, it is seven feet, mostly bituminous, and with a clay parting. At Willkesbarre, Pennsylvania, it forms the *big vein*, varying from 7 to 20 feet. At Carbondale it has 12 feet of coal, divided into five sections by four clay partings. The true member, viz: the one covered by shales, containing the characteristic plants, is six feet thick.

The celebrated bed of summit Lehigh, measuring in its whole thickness about 50 feet of strata, of which nearly 30 feet is coal, and the balance, a number of slates and clay partings, is also referable, by its plants, to our No. 1 B, connected with both 1 A and 1 C; all these coals divided and considerably thickened by a geological phenomenon. Its medial part, covered with the shales and plants of this coal, is six feet thick.*

It would be easy to give a greater number of sections, but these will suffice to show the remarkable distribution of this vein of coal; the other variations worth mentioning in Kentucky will be reported in the enumeration of the coal beds of each county.

COAL NO. 1 C. PALÆONTOLOGY AND GENERAL DISTRIBUTION.

If this bed of coal had not some palæontological characters entirely at variance with those of the former, it would be better, perhaps, to take it in connection with them.

In its separate form, it generally appears covered with a kind of ochreous, laminated, and rolled clay, breaking into small irregular pieces, like pieces of decayed wood. It is rarely covered with shales, but when they are present, they appear as if formed by a superposition of stems, especially stems of ferns of undeterminable species. This shale has above it either a bed of sandstone, limestone, or limestone ore. In this

* To prevent a new accusation of plagiarism, I may mention that all the sections, given without reference, were made by myself, and that for every one of them I ascertained, by palæontological evidence, the place of the coals reported. For the purpose of comparing the palæontological characters of the coal strata, I spent, in 1857, a few months in explorations through Ohio and Pennsylvania, re-visiting again most of the localities which I had explored as assistant in the Geological Survey of Pennsylvania. These explorations were made at my own expense, and cannot be claimed as the property of the Director of the Geological Survey of Pennsylvania.

latter case, the ochreous clay, which covers it, is, like the limestone, abundantly fossiliferous. But when the limestone is not formed, the yellow clay shales of the roof bear no traces of fossils of any kind. The coal of this vein has a peculiar appearance, which may help to identify it. It looks, as the shales, like a compound of broken stems, of which the forms are obscurely preserved by charcoal, or sulphuret or oxide of iron. This coal is, therefore, of inferior quality, yet it is worked sometimes, and proves a good coal for blacksmiths. Its thickness varies from one to three feet, and rarely attains four feet.

This vein is called limestone coal, because of its position below a limestone, or limestone ore, of variable thickness and inconsistent distribution. It would, perhaps, be better to say that this coal occupies the place of a bed of limestone; for, generally speaking, when the limestone is fully developed, the coal is scarcely formed. Its distance from No. 1 B is from one to fifty feet.

There is nothing in the western coal basin of Kentucky which, within the present range of my observations, could be referred to this vein, except, perhaps, the vein mentioned as having been found about 60 feet above Bell's coal, in Crittenden county, and the top bed of coal at Hawesville. (The former of these veins has not as yet been examined.) Our No. 1 C was not crossed in Holloway boring, where its place is filled by black shales; at Greenville it is apparently replaced by limestone.

In the eastern coal fields this coal is not often developed, but its place is marked by large boulders of septaria, or yellow ferruginous limestone, seen at from 10 to 45 feet above coal 1 B. On Quicksand creek, near Jackson, Breathitt county, the cannel coal, at Mr. J. Roark's, is overlaid at 15 feet distance by a bed of black, polished, very bituminous shales, filled with stems and *Stigmaria*, which probably indicate its place.

Eight miles above the mouth of Blackwater creek, in Morgan county, on the property of Mrs. Dennis, the limestone is formed, but the coal is not present, or is connected with No. 1 B; the section is as follows:

	Feet.	Inches.
Shaly sandstone	20	
Limestone in layer		2
Micaceous shales		4
Hard sandstone, resembling whetstone		6
Gray micaceous soft shales		2
Bituminous coal	1	3
Gray soft shale parting, with plants of No. 1 B		3
Bituminous coal		4
Brashy coal, with plants		2
Bituminous coal		2
Fire clay and covered space	2	

In Greenup county this coal takes a distinct position, with its proper characters, and it is in this same county that we see the first appearance of the buhrstone, a peculiar formation, largely developed along Flint ridge, and some localities of Ohio, above this coal. This buhrstone is, in Greenup county, a compound of large pieces of blue and greenish flint, mixed with charcoal, or woody fibres, hardened by sulphuret and oxide of iron. It is often covered by large, apparently multiple layers of bark of *Sigillaria*, badly preserved, and transformed into flint. This kind of stone is seen along the railroad from Ashland to Mr. Welsh's store, at the foot of the Stinson hills, overlaying either No. 1 C, or the limestone above it; it generally breaks in great regular cuboidal pieces.

Near the Buena Vista furnace, coal No. 1 C is 20 feet above cannel coal 1 B, and just below the limestone ore. At Greenup mines, on the land of the Kentucky Coal Oil Company, of Ashland, the same coal is also 20 feet above the main cannel, and is here two feet thick, rusty, and full of stems. The rusty color of this coal appears to be general. In this last locality it has no limestone above it; but around Buena Vista furnace both limestone and ore are sometimes found with it, in which case the coal is very thin. This vein attains its greatest thickness on Brush creek, on the land of the Buena Vista furnace, where, under the guidance of Mr. John Means, the proprietor, I saw it in three places, from three to four and a half feet thick, below the ochreous shales heretofore described. As in the other openings examined, the coal is here also a compound of rusty stems transformed into charcoal, with abundance of sulphuret and oxide of iron.

To the southwest, its geological horizon is marked at Mt. Savage furnace, Carter county, by a bank of black, very bituminous, shales, below limestone ore; and in the same county, at Mr. Jas. Graham's, on Blane

river, a vein of coal two feet thick, referable to 1 B, is overlaid, at about 40 feet distance, by a kind of flinty iron ore. But farther south and westward, every trace of limestone disappears, and the coal loses its characteristics, preserving, however, its place, and being then covered by a sandstone. At Warfield, Lawrence county, judging from palæontological evidence, a bed of coal three feet thick, and one hundred and seventy (170) feet above No. 1 A, is its equivalent. At Paintsville, Johnson county, it is marked by two thin coals, six and eight inches thick, separated by 10 feet of shales, and placed at 40 feet distance from No. 1 B.

Towards the northwest, in Ohio and Pennsylvania, this coal is apparently parted, sometimes by the buhrstone, into two thin beds, one in the middle of this flint formation, and the other between it and the limestone, while the normal branch below the limestone unites with No. 1 B. At Flint ridge, Licking county, Ohio, this branch is only a bed of black slate, charged with so much bitumen that it is used with the coal in the oil manufactories of Newark. The shale mentioned at Mt. Savage posseses the same property; it burns without consuming; containing a great proportion of oil.

I give below, on account of its general interest, the whole section of Flint ridge, made with the assistance of the director of the coal oil factory at Newark, Dr. H. I. Salisbury, with whom I lately visited the mines:

	Inches.	Feet.
Translucent white flint and buhrstone	------	8
Bituminous coal at the base	3	------
Fire clay	------	2
Sandstone	------	50
Carbonate of iron, with thin coal	6	------
Black shales	------	25
Blue hard limestone, with soft ochreous fossiliferous clay below	------	6
C. 1 C. Rich oil-producing cannel slates	------	1
Fire clay and shales	------	4
C. 1 B. Cannel coal	2	4
Black shales, with *Flabellaria, Lingula,* &c.	9	------
Cannel coal	9	------
Fire clay and shales	------	2
Sandstone, with large *Lepidodendron,* &c.	------	31
C. 1. A. Bituminous coal	6	2
Black shales	------	20
Block iron ore	8	------
Sandstone shales	------	20
Bituminous coal	6	1
Conglomerate at base of the hills.		

The block ore here occupies the same geological level as in Greenup county, Kentucky.

At Yellow creek, on the limits of Ohio and Pennsylvania, our No. 1 C coal is the *Rogers* vein, perfectly well characterized by its shales, which are but a compound of stems, and by the nature of its coal. It is three feet thick, separated from No. 1 B by fifty feet of shales, mixed with iron ore. Further west it probably disappears, or is united to 1 B in the formation of a member of the *big vein.*

COAL 2. PALÆONTOLOGY, STRATIGRAPHY, AND GENERAL DISTRIBUTION

The flora of this coal has no peculiar species of its own, as yet discovered—indeed, nothing remarkable, except, perhaps, a greater abundance of specimens of different species of *Calamites*, and of the *Neuropteris hirsuta*, Brgt., and *N. flexuosa*, Brgt., described and figured in the third volume of the Report, plate 6, figures 2 and 4. It also occasionally contains some *Lepidodendron* and their leaves. As the two abovementioned *Neuropteris* are generally found in all the strata of the coal measures, at least between the conglomerate and the Anvil Rock Sandstone, this flora would, apparently, not warrant a separation of coal 2 from No. 1 B coal. There is, nevertheless, an appreciable difference, first, in the general distribution of the flora, and, secondly, in the nature and position of the stratum of shales bearing plants. Coal No. 2 is ordinarily divided by a clay parting of about six inches, (sometimes thicker,) which contains the plants. As the shales of the parting (of light gray color) are generally soft, brittle, exfoliating easily, sometimes like a brash coal, the plants are mostly found in a bad state of preservation, and can scarcely be satisfactorily examined. The number of species is thus apparently limited: *Asterophyllites*, plate IV, figure 1, and the above named species, forming the essential part of the flora. In a single case, viz: at Ironton, I have seen this parting shale becoming black and bituminous, and containing some leaves of *Lepidodendron.* Generally speaking, therefore, the palæontological characters of this vein may be indicated by the absence of *Lingula umbonata;* of remains of large trees, *Sigillaria* and *Lepidodendron,* and of well preserved specimens of ferns.

The roof shales of coal No. 2 offer another reliable character in their total absence of palæontological remains; they are coarse and micaceous; sometimes passing into black shaly sandstone, splitting irregularly across

the plane of stratification, and crumbling in small pieces under prolonged atmospheric influence. They contain no traces of fossils of any kind, neither vegetable nor animal. The coal itself has a peculiar aspect. In the mines it is very black, of good appearance; but when exposed to atmospheric influence it becomes whitish, by efflorescence of sulphate of iron. In its horizontal sections charcoal also appears in greater proportion than in No. 1 B coal. Nevertheless, in some localities, this coal is of good quality, and much used for the forge, as it has a disposition to cake. The fire clay below the coal is soft, white, and suitable for pottery and fire brick.

The division of this coal into two members is not always well defined, and shows some occasional differences, which may lead to errors. It is proper, also, to mention some of these variations of distribution. At Ironton, Ohio, on the property of Colonel El. Nigh, the apparently true shale parting of this vein is three inches thick; but there is above the coal another small vein, separated by a four feet sandstone, which presents a division much resembling some of the partings of coal No. 1 B. In this case the likeness is rendered still more striking by the appearance in the cannel coal, or rather shaly cannel, of leaves of *Lepidodendron*. It looks as if No. 1 B had ascended to No. 2, and was only separated from it by four feet of sandstone. The great, and generally uniform distance between those coal beds militates against such a supposition. It is more likely that a local vein of coal has been formed above No. 2; or, perhaps, that the cannel coal is formed by the increasing thickness of the shale parting, and forms, with the four feet sandstone, the true parting of this coal.

At Gavet's mines, six miles below Louisa, Lawrence county, the distribution is still different. The upper coal has become very thin, and the clay parting shales look like top shales. Then the analogy of the plants with those of No. 1 B might also lead to wrong conclusions. On the opposite side of the river the coal has again taken its natural appearance; has a thin parting clay and the true characters, as before indicated.

The distance of this coal from No. 1 C, either when it is united to 1 B or ascends above it, is, on an average, 100 feet. At Warfield, where the measures increase in an extraordinary degree, it is 280 feet from 1 A. At Paintsville, about 190 feet from 1 B, or 250 feet from 1 A.

I know of no coal in the western coal fields of Kentucky which, by

position or palæontological characters, could be compared with No. 2, except the Ice-house coal, marked 2 feet 6 inches on the 1st diagram of the 1st Report of the Survey, at just 100 feet above the horizon assigned to the limestone coal 1 C. I have reported, volume 3, page 534, all that I know about this vein, which was but just opened on my first tour in Union county, and was covered with water when I visited the place the second time.

Our coal No. 2 is generally well developed in the eastern coal fields of Kentucky, especially in Greenup county, where it forms the Amanda, Ashland, Killgore, Star furnace coal beds, etc. Its average thickness in this county, including the clay parting, is about four feet. In Morgan county it is worked two and a half feet thick, at Hazlerig's mines, opposite to West Liberty; in Breathitt county its place is about 80 feet above No. 1 B, and its thickness is only 20 inches. It attains its greatest dimensions in Lawrence county, where, at Peach Orchard, it is four to five and a half feet, including the parting. Although this coal sometimes has a layer of cannel in it, it is mostly bituminous. Two sections taken from the mines of Peach Orchard, where it has been extensively worked, will show its distribution and its changes in that place:

	Feet.	Inches.
Top sandstone, about	50	
Bituminous coal		2
Brash coal, with broken plants, (shale parting)	1	4
Bituminous coal, with sometimes a band of one inch of pyritiferous shales	4	
White fire clay below.		

Back in the hills, about three miles from the above section, it is:

	Feet.	Inches.
Sandstone	70	
Cannel coal		4
Black shales and iron shales, (parting)	5	
Bituminous coal	3	8
Shales and sulphuret of iron	2	
Bituminous coal		10
White fire clay below.		

At Whetstone creek, Greenup county, on the land of Mr. John Stewart, where this vein has been opened in many places, its thickness, with a clay parting, is from eighteen inches to two and a half feet. At one

of the openings the two members of this coal are separated by 8 to 10 feet black micaceous shales, without fossils, apparently as if another bed of coal had been formed above this one.

Its peculiar distribution at Colonel El. Nigh's, of Ironton, has already been mentioned. The section is as follows:

	Feet.	Inches.
Thick sandstone above.		
Bituminous coal	2	
Hard sandstone	4	
Fine block cannel shales, or cannel coal, with leaves of *Stigmaria* and *Lepidodendron*	1	6
Bituminous coal	1	6
Fire clay and shales		3
Bituminous coal		8

At Pinegrove, two and a half miles northeast of Hanging Rock, Ohio, where this vein is extensively worked, it measures four to four and a half feet, including a clay parting of three to six inches.

The only place, further east, where I had an opportunity to examine it, is at Yellow creek, where it forms the *big vein*. It is there from six to eight feet thick, including a clay parting, having at its base a shaly cannel coal, full of remains of fishes. At Yellow creek it has the same distribution and general appearance as at Peach Orchard, and is also covered by a great thickness of hard sandstone.

It is mentioned by Mr. J. P. Lesley in his manual under the appellation of coal C, or Kittanning bed, the first coal above the buhrstone, as generally developed in the northern part of the bituminous coal fields of Pennsylvania. Its average thickness there is from 3½ to 4 feet. Mr. Lesley makes this coal the great depository of the cannel coal of Pennsylvania, while Prof. M. D. Rogers indicates the coal above it, viz: the lower Freeport coal, as the bed most generally becoming cannel. Not being acquainted with the localities where these geologists took their observations, I cannot decide the question for Pennsylvania. But in the eastern Kentucky coal fields it is our No. 3 coal (consequently a coal higher than the Kittanning) which becomes the main repository of cannel coal.

COAL 3. PALÆONTOLOGY, STRATIGRAPHY, AND GENERAL DISTRIBUTION.

From observations made in former years in Pennsylvania, I had supposed that the plants of the genus *Lepidodendron*, which appear to have

had their greatest development at the time of the formation of coal No. 1 B, had gradually diminished, and, eventually, totally disappeared; so that at the epoch of the formation of the Pomeroy coal there was scarcely any representation of this genus. As yet there is no evidence that this conclusion is erroneous for the Pomeroy coal, (No. 4 coal,) but it is certain now that species of *Lepidodendron*, with their leaves and cones, are found in our No. 3 vein, which is generally formed but a short distance below No. 4. Although specimens of these species of plants have been found in but few of the localities where the bed has been examined, it is sufficient to prove that this beautiful genus had not entirely disappeared from the flora of the coal marshes when this coal (No. 3) was in process of formation.

The shales covering our third vein are generally yellowish gray, or blueish, very soft, and so fine in texture that they are easily divided transversely with the knife. This softness of texture is the cause of the beautiful and distinct preservation of the fossil plants of this coal. Not only have the outlines of numerous fern leaves and stems been preserved in their most delicate details, but the substance of the plants has been transformed into thin lamellæ of coal, so that the roof itself looks like a drawing made on stone by a skillful lithographer. A singular phenomenon often remarked, but still unexplained, is the persistence of the coaly matter of the fossil plants in remaining attached to the lower part of the roof shales, so that pieces detached from the roof have, generally, one side imprinted with the forms of the leaves only, while the other preserves the carbonized vegetable matter.

There have been but few opportunities for a favorable study of the palæontology of this coal. In the western coal fields it is generally connected with a calcareous black band, and its shales becoming bituminous and black, have preserved only the most durable parts of the fossils. In the eastern coal fields of Kentucky this vein is placed too high in the hills to be easily worked; and though its outcrops are numerous enough, it has been nowhere extensively worked, except, perhaps, at Stinson hills, Greenup county, at Grayson, Carter county, and at Haddock's mines, in Breathitt county.

The most abundant of the fossil remains at Stinson's belong to *Dictyopteris obliqua*, (pl. 1, fig. 1;) to *Sphenophyllum Schlotheimii*, Brgt., (pl. 4 fig. 2,) to *Annularia fertilis*, Stern., (pl. 4, fig. 4,) and especially to

Asterophyllites tuberculata S., (pl. 3, fig. 3;) *Neuropteris hirsuta*, and *Pinnularia*. On the roof shales there are a few specimens of *Lepidodendron elegans*, Brgt.; the long *Lepidostrobus*, which Mr. Brongniart has named *Lepidostrobus ornatissimus*, from its great size; branches of *Pecopteris*, apparently *P. oveopteridius*, Brgt., and *Sphenopteris latifolia*. At Haddock's there is an abundance of *Calamites*, especially *Calamites decoratus*, Brgt., (pl. 3, fig. 4,) which is also found in Pennsylvania in connection with the same vein, and may belong to it exclusively. Then *Hymenophyllites Hildreti*, Lsqx., (pl. 2, fig. 5,) a plant abundant also in the shales of No. 1 B. *Alethopteris Serlii*, Brgt., (pl. 1, fig. 3,) common at Zanesville, Ohio, in coal No. 3, and at Room run mines, Pennsylvania, and *Pecopteris unita*, Brgt., (pl. 2, fig. 2,) probably particular to this vein, or, perhaps, ascending to the Pomeroy coal. I have seen in this coal no traces of *Sigillaria*, nor of fruits of any kind, except the long cones of the *Asterophyllites* and *Lepidostrobi*. Some species, apparently new, were found at Stinson hill, but the shales were too soft to be transported. Moreover, this vein is not worked now; the tunnels were full of water, and it was with difficulty that I could detach from the roof a few pieces for a too hurried and unsatisfactory examination.

Besides the nature of the shales, the perfect preservation of the fossil plants, and the predominance of the named species, there is yet another character which may help to identify this vein. It is generally overlaid by a bed of limestone, separated from the shales of the coal by a space of 5 to 20 feet. The thickness of this limestone, which is somewhat more consistent than any other limestone of the coal measures, varies from one to eight feet. The nearer the limestone lies to the coal, the more black, and more bituminous, the shales become. When it comes in contact with, or in close superposition to the coal, as in Muhlenburg and Christian counties, this limestone is often replaced by a very productive black band iron ore, whose remarkable color (an alternation of red, or chocolate, and black stripes) prevents its being mistaken for any other black band of our coal fields. The limestone above this coal is generally present in the western coal basin, as well as in Greenup county. It caps the Stinson hills; it is found at Catlettsburg, and at the top of some of the highest hills, forming sometimes a bastard, or rather porous and somewhat cherty limestone. In the southeastern part of the east coal

basin it entirely disappears, as well as all other beds of limestone, and is replaced by thick strata of sandstone, with some iron ore.

This difference in the intermediate strata renders the distance of this coal from No. 2 somewhat variable. On Stinson hill and at Grayson, where, as before said, the thickness of the coal measures is considerably reduced, the distance between these veins is about 85 feet. At West Liberty, Morgan county, (Cox's vein,) it is 110 feet. At Haddock's, on the Kentucky river, No. 2 is not formed (at least is not visible) on the same hills where No. 3 is worked, and its distance from No. 1 is 275 feet. Below Louisa, in Lawrence county, No. 2 and No. 3 coals are, apparently, 100 feet apart. At Warfield, 140 feet. At Paintsville, about the same distance. It is unnecessary to state that the distances here indicated, like all others in my Report, are approximative; *i. e.*, as accurate as a measurement with the pocket level can make them.

In the western coal basin of Kentucky, along the Ohio river, this coal, near Caseyville, is represented below the Curlew limestone by a thin streak of coal. At Hawesville it is 20 to 30 inches thick, and along the southern edges of the same basin, in Muhlenburg and Christian counties, it varies from 6 to 30 inches, its greatest thickness being, probably, at Mr. Larkin Campbell's, 2 feet 10 inches.

The Hawesville upper coal has been the subject of much discussion, and its place is still uncertain. In the fourth diagram of the first volume of the Reports, it is marked 205 feet above the main coal, which, from palæontological evidence, I consider as the equivalent of No. 1 B. This would be just the place of No. 3. Still, the general characters of the Hawesville upper coal are not the same as those usually indicated by this vein. The coal is bituminous, much charged with pyrites, like the top coal of the Raccoon furnace, and is separated from a 9 feet stratum of fossiliferous limestone by a brown ochreous clay, resembling that which sometimes covers No. 1 C. This brown clay, like the limestone, contains an abundance of fossil shells, especially *Terebratulæ and Encrini es*, just like the Curlew limestone. The absence of the intermediate sandstone, separating at o her localities coal No. 3 from the limestone, has, perhaps, caused the difference in the nature of the shales, and, consequently, substituted shells in the place of plants, which cannot exist where the marine influence has had full sway. At any rate, the upper coal at Hawesville,

so far as can be judged from the present observations, belongs, in all probability, to the coal horizon of No. 3.

Here I would take occasion to remark that we cannot expect to be able to refer every one of our coal beds to one of the divisions indicated by the distribution of the greatest number of them. There are, without doubt, local strata which cannot be referred to any of the geological horizons of our sections. At Mr. John Steward's a coal, 70 feet above No. 2, 18 inches thick, covered with *gray metal* and very soft polished shales, cannot be referred either to No. 2 or No. 3, by its palæontological and external characters, nor by its position. I have not seen this coal anywhere, except at the top of a great bluff of gray metal, near the mouth of Whetstone creek, a tributary of Little Sandy. It was but little exposed at either place. Some similar cases of peculiar distribution may be mentioned in the examination of the counties.

In the eastern coal fields of Kentucky No. 3 is mostly cannel coal of good quality and of workable thickness. At Stinson hill, on the land of Mt. Savage furnace, Greenup county, it has about four feet of coal, distributed as follows:

	Feet.	Inches.
Gray yellowish shales, with plants	6	
Bituminous coal, with one inch clay parting	2	
Black bituminous slates, (bastard cannel)		4
Cannel coal	2	

On the top of the hills above Grayson it has, under a bed of the same shales, with the plants:

	Feet.	Inches.
Bituminous coal		8
Bastard cannel coal		4
Cannel coal	1	6

At Haddock's mines, on the Kentucky river, Breathitt county, its yellow or blue soft shales are covered by sandstone, and underlaid by

	Feet.	Inches.
Shaly or brash coal		4
Bituminous coal	1	2
Cannel coal, (no parting)	3	

This coal is the finest grained cannel of Kentucky. To this No. 3 I refer also a vein of coal, opened at Raccoon furnace, 300 feet above the creek, and about 260 feet above No. 1 B. From measurement, it is thus at the very place which No. 3 should occupy. But, although the shales which cover it are soft, and of the same color as those of coal 3, I could find in them no traces of fossil plants, and, therefore, could not identify it from palæontological data. Its identity, nevertheless, is rendered more probable from the presence of a ferruginous limestone placed at a short distance above it. It is probably the equivalent of the Curlew limestone of the west, and of the Stinson limestone of Greenup county. On Stinson hill, the equivalent of the cannel coal, opened near the tunnel, is bituminous, and has also the yellow soft shales, apparently without fossils. The coal at Raccoon furnace is bituminous, and separated into two members by a parting of gray, soft, brittle, easily decomposed clay.

It is certain that, even in close proximity, the nature of the coal, as cannel or bituminous, cannot be a guide for identification. We have already seen the Stinson cannel coal becoming bituminous at a short distance. At Warfield, coal No. 2 is opened on three successive hills along the river, precisely at the same level. On the middle hill half the bed of coal is cannel; on the two others it is entirely bituminous. At and around Ironton, the same vein is always bituminous, except at Col. El. Nigh's vein, where it is mostly cannel.

On Mr. John Steward's property, on Whetstone creek, Greenup county, there is also a coal, occupying the same horizon as No. 3, and of which the shales are yellowish, soft, and without fossils. It is 130 feet from No. 2, appears in two members, and is said to be cannel. I could see nothing of this bed except the yellow shales, and very small pieces of that. Above this vein, separated from it by 10 to 15 feet of shaly sandstone, or shales, the Mahoning Sandstone sets in and caps the hills, in a thick, hard, conglomeratic stratum. As from the double stains, this coal appears in two beds; it might be possible that coal 3d and coal 4th are here in near proximity; but no trace of limestone is to be seen above it, and our coal 3d is sometimes separated in two beds, like this one.

COAL 4. PALÆONTOLOGY, STRATIGRAPHY, AND GENERAL CHARACTERS AND DISTRIBUTION.

The characteristic plants of the roof shales of this vein are especially small species of ferns. Among the *Neuropteris*, it has *N. flexuosa*, Brgt., in the greatest abundance; *N. Loschii*, Brgt.; *N. dentata*, Lsqx.; *N. heterophylla*, Brgt., and the remarkable *Cyclopteris fimbriata*, Lsqx., a beautiful, large, nearly round, fringed leaf of fern. The genus *Sphenopteris* is represented by *Sphenopteris Gravenhorstii*, Brgt.; *S. Dubuissonis*, Brgt.; *S. abbreviata*, Lsqx.; *S. intermedia*, Lsqx.; and *S. plicata*, Lsqx.; all species rarely found, and seen only in the anthracite basins of Pennsylvania. This vein has all the representatives of a peculiar genus, (*Schizopteris* of the authors,) published in the final Report of Pennsylvania Survey, under the name of *Pachyphyllum*, Lsqx.* The plants of this genus are thick, with leaves irregularly divided, sometimes quite smooth, sometimes covered with hair. This vein, No. 4, has scarcely any *Alethopteris*, but the greatest abundance of *Pecopteris*, viz: *Pecopteris polymorpha*, Brght.; *P. notata*, Lsqx.; *P. oreopteridis*, Brgt.; (this last found also with No. 3;) *P. pusilla*, Lsqx., especially *P. arborescens*, Brgt., (*pl.* 2, *fig.* 1;) *P. cyathœa*, Brgt., (perhaps a variety of the former;) and *P. arguta*, Brgt., (pl. 2, fig. 3.) These last three species appear to be the true characteristic plants of this vein, and not found elsewhere. It also, like the former coal, contains a great abundance of *Asterophyllites*, *Sphenophyllum*, and their fruits, with *Pinnularia*, apparently a kind of root, dividing itself in innumerable threads, like branches. It covers sometimes, by itself alone, great surfaces of the roof of the mines. This vein does not appear to have any remains of *Lepidodendron* in its shales, at least none has been found till now. But it has still some *Sigillaria*, especially those of the section of the *Leioderma*, which are not marked with longitudinal furrows: *Sigillaria sculpta*, Lsqx.; *S. obliqua*, Brgt.; *S. fissa*, Lsqx., and some *Calamites; C. cruciatus*, Brgt.; *C. ramosus*, Brgt., which, perhaps, belong to the same species, and exclusively to this coal. Thus, this vein is well marked in its peculiar flora by the abundance of small ferns, and the deficiency of large trees, of stems of *Lepidodendron*, and of fruits. It has, like No. 1 B, *Flabellaria* in abundance.

In his excellent Report on the Geology of Ohio, Dr. Hildreth, of

* Fossil flora, of the final Report of the Pennsylvania Geological State Survey, vol. II, p. [illegible], pl. 8.

Mar'e'ta, has thus briefly characterized this flora: "*In the shales twenty species of plants, Equisetaceæ, Filices numerous, Lycopodiaceæ rare.*" The *Calamites* belong to the *Equisetaceæ*, the *Lepidodendra* to *Lycopodiaceæ;* the *Filices* are the ferns.

Lithologically, this vein, No. 4 is easily distinguished from No. 3 by the hard, micaceous texture of its gray shales, and by its position at the base of a great, hard, mostly conglomeratic sandstone, 20 to 100 feet thick, which overlays it sometimes without the intermediate shales and plants. In this case coal 4 resembles C. 1 A; the more so as the Mahoning Sandstone, like the sandstone above 1 A, contains large pieces of fossil woods. But there is a great difference in the consistence and thickness of the sandstones. Moreover, the fossil remains of the Mahoning Sandstone are not merely prints, but pieces of wood transformed into charcoal, or silicified trunks, belonging, a few of them, to *Calamites*, and mostly to *Sigillaria* and *Psaronius*, or fern trees.

Among thousands of specimens examined in Ohio, Athens county, I have not found a single *Lepidodendron*. This Mahoning Sandstone, often a conglomeratic or pebbly sandstone in its upper part, attains a great development near Pomeroy, Ohio, where it measures more than 100 feet. In the S. E. part of the eastern coal fields of Kentucky, viz: at Warfield, its thickness is 200 feet. It does not appear to thin much toward the west, since in the western basin, in Muhlenburg county, it is 75 feet thick, and even more.

The coal of this 4th vein is of excellent quality; indeed, for domestic use and generation of steam, it is one of the best of the coal measures. It and the best Pittsburg coal are the only coals, I believe, of which the coke has been used in the west for smelting iron in place of charcoal. The old Pennsylvania furnace, in Muhlenburg county, used it profitably for a long time. The vein is generally compact, sometimes divided in two by a thick shale parting, and its average thickness is from 3 to 5 feet. Near Pomeroy, Ohio, it is 6 feet thick. In the southern part of the western coal basin of Kentucky, where it has been opened in many places and considerably worked, it is generally 3 to 3½ feet. At G. Terry's, near the county line of Hopkins and Christian counties, the coal is 4½ feet thick, &c.

The distance of this vein from No. 3 is short and not very variable. Under the Waugham coal No. 3 is found 25, at the most 30, feet lower

in the creek. In the vicinity of the old Pennsylvania furnace there is generally 25 feet of measures between both veins. In Greenup county coal No. 4 has not been seen; its place is marked by black shales, placed above the limestone. At Ironton, opposite Amanda furnace, where the section is easily followed on the same hill, its place is still occupied by shales, and coal No. 3 is 30 to 40 feet below the base of the pebbly Mahoning Sandstone. In Lawrence, Johnson, and Floyd, the place of this coal is not positively ascertained. It is too high in the hills; and, though some outcrops have been seen, which, by position, might be referred to it, it was not possible to have any of them either opened or exposed, to satisfactorily study the characters of the shales. In the anthracite coal fields of Pennsylvania this vein, like the former, is generally well developed, distinctly marked by the fossils of the shales. It furnishes to the trade the kind of mineral coal named *red ash*, from the color of its ashes.

THIRD DIVISION. COAL MEASURES BETWEEN THE MAHONING AND ANVIL ROCK SANDSTONES.

While between the conglomerate and the Anvil Rock Sandstones the characters of each vein of coal are taken especially from the fossil plants preserved in the shales, in this higher division of the coal measures we cannot find in Kentucky any reliable guide in the vegetable kingdom, at least from the distribution of peculiar species.

Generally, the plants found in connection with the coal strata of this division are much broken, or rather obliterated, mostly replaced by marine shells, or even intermixed with them. This shows a predominance of marine influence in the formation of the shales. Either the water covering the coal marshes, after the formation of the combustible matter, became too deep to permit the continuation of an abundant vegetation on their surface, or the remains of the plants have been too much decomposed in the water, and hence obliterated in the shales. It is, nevertheless, evident that the same vegetation, which caused the formation of the coal strata of the former division, had the same action in the formation of the coal beds of this section. Some roof shales, like those of our coal No. 9, contain well preserved remains of *Pecopteris*, *Sigillaria*, and *Calamites*, with numerous remains of shells. In the sandstone strata of this division, also, are imbedded remains of broken plants, pieces of wood, trunks of trees, all belonging to the same genera of plants as those of the former

section. These vegetable fragments in the sandstone are generally thrown into confusion, or without any apparent order, either of direction or of stratification. It shows that they have been carried and transported by waves, or currents, and irregularly deposited on shores. But the nature itself of the shales, and the shells and the plants which they contain, is evidence that these shales have been deposited, like those of the former division, in a quiet and shallow body of water.

In the eastern coal fields of Kentucky, the upper division of the coal measures has been entirely washed away, and no trace of it left. On the contrary, in the western coal basin, the true coal-bearing formations the most easily attainable, and those which contain the best and thickest coal strata, have their place above the Mahoning Sandstone. This part of our examination, therefore, is exclusively confined to the western coal basin.

Though the first geological reconnoissance made in the western coal basin was too short and hurried, it, nevertheless, afforded important results, since a more careful revision of most of the localities previously examined, has not changed my views about the general characters of the veins of coal and their distribution. It has not, therefore, caused any modification in the determination of the coal strata, or in the place assigned to them in my Report and that of Mr. C. T. Cox. But since a greater number of coal banks have been examined, and their peculiar appearance compared at many places, it will be necessary to make now a short review of their general characters, to mention additional facts which have been ascertained by the examination of the new localities.

Coal 5th. This had not been seen in the first tour of exploration. It is characterized by a thick bed of black, polished, hard shales, sometimes a little micaceous, splitting horizontally in large slabs, entirely barren of any traces of fossil remains, either animal or vegetable. This coal is locally of good workable thickness. On Richland creek, Hopkins county, it is 5 feet, and its roof of black slates 12 feet thick. In the upper part of the bank the shales are somewhat whitish, spotted like those of No. 9; but they have no trace of fossils. At Mr. Robertson's bank, near Greenville, Muhlenburg county, the coal is 18 inches thick, underlaid by 18 inches of brash coal, and covered by 6 feet of black slates. The thickness of the bed of Richland creek is given as it appears in the outcrop. Perhaps it is somewhat overrated, for generally

in Hopkins county this vein is no more than 2 to 3 feet thick. At Mulford's, and along the Ohio river, it is reported 4 feet, and known as the *Four-foot* coal.

Though this coal belongs to what has been generally called the barren measures, of the Pennsylvania Report, it is found of workable thickness in Ohio, and even in Pennsylvania. Dr. Hildreth has reported it as being 4 feet thick, and 120 feet above No. 4. He calls it appropriately the limestone coal; for it is generally covered by a stratum of this material. In Pennsylvania this vein is marked by Mr. J. P. Lesley as coal G, one foot thick, placed below a limestone, at 125 feet from No. 4. And in the final report of the Survey of Pennsylvania, vol. 2, p. 656, it is reported as placed below calcareous shales, at about the same distance (125 feet) from the Pomeroy coal. In western Kentucky the distance of this coal from No. 4 varies according to the thickness of the Mahoning Sandstone. It averages 100 feet.

Coal 6th. The characters reported, vol. 3, p. 537, are, apparently, constant. This vein, like the former, is locally formed and of variable thickness. At Mr. E. L. Johnes', near the old Buttermilk road, Hopkins county, it is 4 feet thick, and the coal is of fine appearance and of very good quality. It is hardly as thick elsewhere. At Greenville, Muhlenburg county, it lies just at the top of the great limestone and 70 feet above No. 5. In the Airdrie shaft, on Green river, it is placed at the same distance, and is also a thin coal. In Union county it has been seen only at Mulford's. Except what has been reported, p. 538 of the 3d volume of this Survey, I have no data by which I could ascertain its position in Pennsylvania and Ohio.

Coal 7th. I formerly referred to this number the following vein No. 8. Our coal 7th is the Well coal of Mulford's shaft. It has peculiar characters distinct enough from those of No. 8. I had an opportunity of seeing it partially opened at Curlew, Union county, the last time I visited the mines. At this place the coal is about 2 feet thick, overlaid by very black, soft, polished shales, resembling those of No. 5, with the exception that they do not split in large slabs, but in small pieces, and that they contain teeth and scales of fishes. The teeth are very small, scarcely an eighth of an inch long. There may be other fossil remains in the shales, but I did not find any. The most reliable and evident character is the great abundance of pebbles of carbonate of iron in the shales over-

laying the black slates. This vein never was seen of any great thickness, so far as I know.

To this 7th coal may be probably referred a bed, 13 inches thick, crossed in digging a well on the property of Mr. I. Short, at Greenville, Muhlenburg county. It was reached at 25 feet from the surface. A short distance above this coal the shales, from the statement of Mr. Short, contained fine specimens of fern leaves. Unhappily none of the specimens could be found and examined. In the blue shales of the barren coal measures, near Athens, as also in the red shales of the Grotto of Flowers, near Marietta, there is an abundance of leaves of a peculiar species of fern—*Asplenites rubra*, Lsqx.—which is, perhaps, identical with the plant found at Mr. Short's. This would be the more remarkable, as, at both places, the shales contain carbonate of iron and traces of coal. Thus the identity of the plants would show the place of our coal 8th in the barren measures, where it has not been formed. From stratigraphical observations the place occupied by those fern-bearing shales in the "*barren measures*" of Ohio, would correspond with the place of the Well coal. The Isinglass Lick coal, of Hopkins county, reported vol. 2, p. 326, has also the characters of this vein, and evidently is its equivalent.

If any part of the space comprised between coals No. 5th and 9th, properly deserves in Kentucky the name of barren coal measures, it is the 250 feet, including the above named 6th and 7th coals, which, not being persistent, are not altogether reliable beds, and have been but little worked anywhere. The characters of their shales are still somewhat obscure, and not perfectly reliable, and require to be verified by further comparisons.

Coal 8th. The appearance of this vein is so attractive, although fallacious, that it has been opened for examination at a great number of its outcrops. It is improperly called the *Black-band*, of Hopkins county, and is a compound of black, heavy, compact limestone, resembling a fine iron black band, and of black, hard, compact, bituminous slates, resembling cannel coal. Its palæontology is mostly remains of animals. It has, among many species of large shells, an extraordinary quantity of a very small species, scarcely visible to the naked eye, and which is strewn over the shales like innumerable grains of sand. It also contains abundant remains of fishes, especially the double teeth, mentioned with coal

No. 12, vol. 3, p. 548. Two species of plants were found in the shales of this coal, both apparently of marine origin. The one, *Calamites gracilis*, Lsqx., (pl. 3, fig. 5,) a long, narrow *Calamites*, a quarter of an inch in thickness, bearing obscure sheets, like the *Horsetail*, (*Equisetum*,) and thus, if the appearance is not fallacious, a true *Equisetites*. I only found one specimen of this plant. The other, a long blade, or leaf, enlarging toward the top, and resembling a *Flabellaria* without the striæ or longitudinal grooves. Both are undistinctly marked on the black shales.

The coal of this vein is thin. Indeed, it can be called a barren vein, since the black shales, though very bituminous, and sometimes inflammable, do not consume like coal. In a few openings the coal has been found to be one to one and a half foot thick, but no more. The following section illustrates the most general distribution of this vein. It is taken at the Black-band, of Michel's heirs, Hopkins county, near Mr. A. Towns' property:

	Feet.	Inches.
Shales and sandstone, covered space	10	--------
Black slates, spotted and splitting	1	--------
Soft crumbling shales, with shells	1	3
Hard bituminous cannel slates	--------	6
Black heavy limestone, (black-band)	1	--------
Gray, hard fire clay, with boulders of sulphate of lime	--------	6
Yellow ferruginous clay, with boulders of limestone	3	--------
Dark, gray, hard fire clay	1	6

The black limestone and the hard bituminous slates vary in thickness from a few inches to two feet, yet preserving their color and appearance.

The distance of this No. 8th from No. 7th is not known to me in a positive manner, as No. 8th was not seen in the area occupied by this vein; but it is generally from 20 to 25 feet from No. 9th.

Its distribution is limited to the southwestern part of Hopkins county, where it occupies a basin traversed by the Henderson and Nashville railroad. It is mostly seen on the waters of Richland, Steward, and Clear creeks, and their branches. It extends, probably, in a narrow spur in Muhlenburg county, where it crops out at Mr. E. R. Veirs', two miles north of Greenville.

Coal 9th. This fine bed of coal has been examined in a number of openings, and its characters closely compared, without eliciting any change from the description given in the former Report, pp. 541–2. Neverthe-

less it must be remarked, first, that the shales bearing fossils contain well preserved branches of ferns, (especially *Pecopteris Miltoni*, Brgt.,) and of trees, (especially *Sigillaria*,) together with specimens of shells, (especially *Avicula rectelateraria*, Cox, and *Productus muricatus*,) sometimes all together, plants and shells on the same piece of shale; secondly, that the fossil shells and the remains of fishes are sometimes rare in the shales, and that they must be looked for carefully. The peculiar hardness of its fire clay and its striped dark color is a persistent character.

The distribution of this vein in Pennsylvania is now ascertained, though its place is not marked in Lesley's manual of coal, and it has not been mentioned in Ohio. It was first identified by its palæontological characters at the base of the great cut, near the tunnel, about two miles east of Greensburg, Pennsylvania, with its hard fire clay and about 18 inches of coal. It is there covered with black shales of the same character as in western Kentucky. And, recently, my excellent friend, Prof. W. D. Moore, of Oxford College, Miss., being on a tour of exploration around Pittsburg, collected and forwarded to me, for examination, a box of specimens of shales covered with *Avicula rectelararia* and *Pecopteris Miltoni*. These shales, from the observation of the learned Professor, overlay a bed of coal 1 foot thick, exposed close to the track of the Allegheny Valley railroad, fifteen miles above Pittsburg. From the nature of the shales and the species of fossils which they contain, this vein is evidently identical with our No. 9.

In the final Report of the State Geological Survey of Pennsylvania, the only coal which, by position, may be referred to No. 9, is the Elk Lick creek coal, marked about 60 feet lower than the Pittsburg coal. It varies in thickness, from one foot at Elk Lick creek to three feet at Ligonier.

In Kentucky the thickness of this vein does not vary much. It averages 5 feet of good bituminous coal, scarcely, if ever, cannel coal, generally without a clay or shale parting. It is the most extensively worked bed of the western coal basin, and its coal is of excellent quality. Its distance from No. 11 varies from 60 to 100 feet.

Erom a note received from Mr. Patterson, director of the Airdrie iron furnace and coal mines, it appears that, in the shaft at that place, coal No. 9 is underlaid by a bank of gray, hard, compact limestone, 3½ feet thick, abundantly fossiliferous. It is separated from the coal by only 3

feet of clay and shales. This limestone cannot be supposed to be the equivalent of the false black band of Hopkins county. It is quite different in texture, color, fossils, &c. It is remarkable that no limestone has been observed before on the same geological horizon, and that the Airdrie shaft section has already been twice reported, on apparently good authority, without this limestone being mentioned.

Coal 10th. This vein has been only seen on the hill at Mulford's coal mines company, with the same characters as those indicated, vol 3, p. 544. It is, probably, a separated member of No. 11. It has not been seen in Hopkins county, although the space between No. 9 and No. 11 is often exposed for exploration. At Airdrie, and along Green river, the shafts and numerous borings between No. 11 and No. 9 have not found it anywhere. It would thus appear to be developed only along the Ohio river, in the vicinity of Shawneetown and Mulford's.

Coals 11th and 12th. Like No. 9th, they have been examined at many new openings, and appear to preserve exactly the characters formerly reported. The vein No. 12th is so often in such close proximity to, or in connection with No. 11th, that it may be regarded as one of its members. Both these beds of coal stand in nearly the same relation as the three divisions of our coal No. 1.

The extension of these veins is finely exemplified near Clark's mill, Pond river, on the limits of Muhlenburg and Hopkins counties. The section of the cliffs, as reported in the first volume of the Survey, page 136, is:

	Feet.
Covered space, shales and clay iron stone	6 to 10
Coal, (No. 12,) bituminous	2
Yellow, somewhat coarse shales	10
Limestone	2
Coal, with clay parting	5

Thus both veins, 11th and 12th, are here separated by 12 feet of measures, of which two feet are limestone. Since the above section was made, the coal has been entered by a tunnel, cutting through both beds of coal and the intermediate strata. Only 14 feet from the entry, within the tunnel, the appearance of the measures is already totally changed. The limestone, which, from the outside, looks like a continuous bank, has entirely disappeared; first thinning, then changing into a yellow ferruginous clay, soon lost with the shales. Now, at the place mentioned, 14 feet from the entry, the fire clay of No. 12th has become the roof of No. 11th, and the distance between the base of No. 12 coal and the top of

No. 11th is only two feet. Somewhat further, both coals appear united, only separated by six inches of black shale parting, containing the fossils of No. 11th, and the bed is 7 feet thick. The limestone which covers the entry has an horizontal breadth of but 7 feet 3 inches.

Such divisions in the veins No. 11th and 12th have given rise to a great deal of discussion among the geologists; some being led to the conclusion that several strata of coal do exist, where really but one is found. It is, therefore, important to follow those changes in good authenticated sections. On this matter none are more instructive than the borings carefully recorded by Mr. Achison, and made at and around Uniontown, Union county, in searching for a thick bed of No. 11 coal. At the first boring, mouth of first branch of Dry Fork of Highland, the Anvil Rock Sandstone is in three members 53 feet thick, and at its base, 111 feet from the surface, a three inch coal is found running into it. From this down for 60 feet the section is:

	Feet.	Inches.
Hard green sandstone	2	--------
Coal	1	10
Fire clay	--------	6
Hard gray sandstone, slaty sandstone, and shales	22	3
Coal No. 12th	3	3
Brown slate	1	10
Limestone, in three beds	15	10
Slates	7	2
Sandstone	5	--------
Coal No. 11th	5	--------

On Main and Second streets, in Uniontown, the base of the Anvil Rock Sandstone (18 feet thick) is marked at 90 feet from the surface, and overlies a coal 20 inches thick. The section then continues:

	Feet.	Inches.
White rock, mixed with clay and blue shales	16	2
Coal No. 12 at 112 feet from surface	2	3
Fire clay	2	1
Limestone clay	5	1
Hard white limestone	2	10
Blue shales, with limestone	12	8
Hard limestone	--------	5
Bituminous shales, limestone, and clay	4	--------
Hard limestone	4	--------
Soft white, blue, and black clay	--------	8
Coal, 146 feet from surface, No. 11th	5	--------

On the other side of the river, opposite Uniontown, the base of the Anvil Rock is at 131 feet 4 inches from the surface, and there are below:

	Feet.	Inches.
Black shales, with a little coal, (No. 12th)	2	--------
Fire clay	2	4
Gray limestone	--------	6
Hard fire clay	4	8
Gray limestone	1	--------
Hard fire clay, with limestone	6	3
Dark blue shales, with traces of coal, (No. 11th)	4	--------

This is just the place of No. 11th. The boring was continued to 168 feet, through blue shale and limestone, without reaching any coal.

At the boring of Mr. Geo. Payne's, to whom I owe the communication of the records, the place of both No 11th and 12th is normal. Under the Anvil Rock Sandstone, (55 feet thick,) the base of which is at 199 feet from the surface, there are:

	Feet.	Inches.
Blue shales	6	--------
Black shales, with coal No. 12	1	--------
Dark gray limestone	1	3
Hard limestone	3	4
Black slates	--------	4
Coal No. 11	5	--------

The distance between the first three borings is short, not more than half a mile. The boring of Mr. Payne's was made at his house, in the hills, four miles south of Uniontown. In the first boring, there is between No. 11th and 12th coals 30 feet of strata, of which about 16 feet is limestone. On the second boring, the same thickness of measures contains about 22 feet limestone. At Mr. Payne's, the separation of the coals is about the same as reported (vol. 3, p. 547) for the McNary's coal bank, and the limestone is only four and a half feet thick. These differences of distribution, if exposed to view by outcrops, and not ascertained by borings, could not fail to mislead the observer whose researches are not directed by palæontological evidence.

Coal 11th is locally underlaid by a yellow, drab-colored limestone, without or with but few fossils. Like the other banks of this kind, it takes, at some places, a considerable development, and at others, disappears entirely. Under the Llwellyn's and Watson's mines, Hopkins

county, it is 12 feet thick. At Providence it is absent. At Buffalo Mt. its greatest thickness is apparently four feet. It does not appear to be formed any where in Muhlenburg county and along Green river, but is marked in the Holloway boring, at Henderson. Both the limestones above and below No. 11th are locally replaced by limonite iron ore, or by a kind of ochreous soft iron ore, widely distributed in Hopkins county, where it can be traced from Buffalo Mt. to Montezuma, on the Tradewater river. It is sometimes in beds of one to three feet thick, and contains as much as 40 to 45 per cent. of iron.

Before concluding these general remarks, it is necessary to correct an important error of my former Report. From comparison of fossil shells found at the great vein near the tunnel of the railroad, three miles east of Greensburg, Pennsylvania, with those of our No. 11th coal, the identity of both veins had been ascertained. I had also identified, in the cut of the railroad near the same place, the fire clay of a vein of coal 70 feet lower than the great vein, as being the equivalent of No. 9th, (vol. 3, p. 541.) From the position of the big coal of Greensburg, between two thick banks of limestone, I had supposed that it was the coal of the great limestone of Pennsylvania, and, consequently, admitted a lower coal, viz: No. 8th, as the equivalent of the Pittsburg vein. Now, from the final Report of the Geological Survey of Pennsylvania, which has just been published, it is evident that the great vein of Greensburg is the equivalent of the Pittsburg coal, and, consequently, that this celebrated vein finds, in the western coal basin of Kentucky, its representative in our Nos. 11th and 12th coals. This is truly remarkable, and fills up the measure of analogy in the distribution of the veins of coal on both the basins of Pennsylvania and of western Kentucky.

Independent of the fossils and other characters indicated above, the identity of our No. 11th coal with the Pittsburg may be sustained by the following considerations:

1st. In Pennsylvania, the Pittsburg coal is generally separated into two seams, either by a shaly parting or by thick layers of shales, or even by sandstone. We have seen our No. 11th and 12th veins connected, or divided, in the same manner. Only the separating member between our coals is generally a limestone, and the distance of separation is sometimes greater.

2d. The Pittsburg coal often appears between two strata of limestone,

It is the same with our No. 11th, which, in Hopkins county, is casually underlaid by 3 to 12 feet of limestone.

3d. The Report of the Pennsylvania Survey says, (vol. 2, p. 505:) "*The characteristic rock above the Pittsburg coal is a massive sandstone, irregularly stratified, weathering with roundish holes,* 30 *to* 50 *feet thick.*" This is just the description of the Anvil Rock Sandstone covering the third division of the coal measures of Kentucky. I may add that, above the tunnel of Greensburg, Pennsylvania, this sandstone contains large trunks of fossil trees of a new genus, and that in Indiana, Posey county, within the area of the western coal basin, Dr. D. D. Owen has found standing trees of the same species in a bank of shaly sandstone and clay, which, from stratigraphical observations, he refers to the same horizon as the Anvil Rock Sandstone.

4th. The great limestone of Pennsylvania, laying about 100 feet above the Pittsburg coal, is sometimes 50 to 70 feet thick, and has below, or within its members, a bed of coal, occasionally thick enough to be workable. In Western Kentucky, one hundred feet above No. 12th, we have a thin coal, No. 13th, and above it two great banks of limestone, separated by shales. The thickness of both banks vary from 15 to 30 feet.

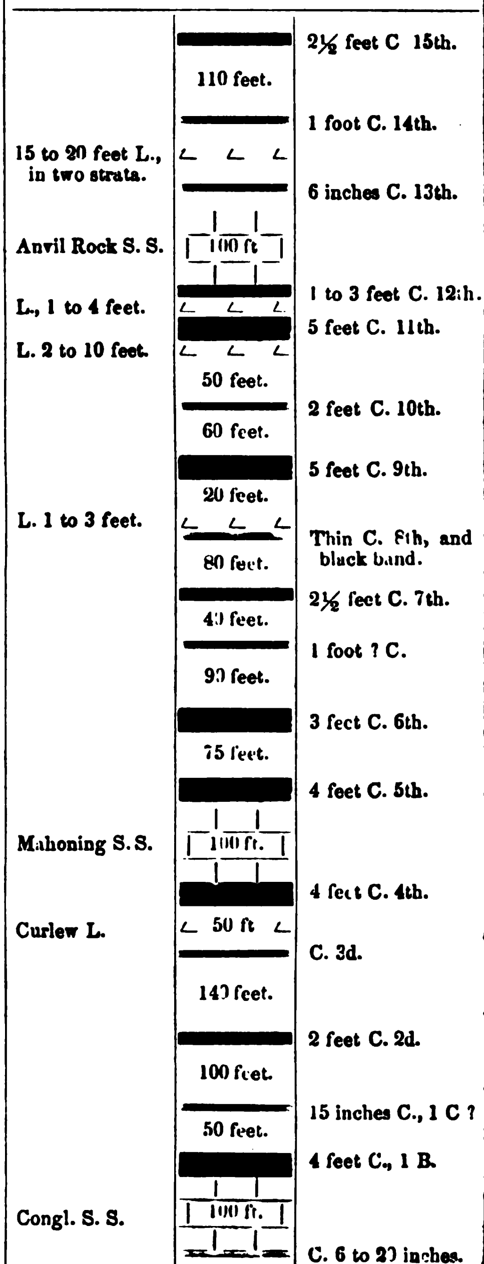
6th. Another coal in Pennsylvania shows itself 200 feet above the Pittsburg coal, and our No. 14th coal, one foot thick, is 180 feet above No. 12.

7th. The Waynesburg coal, in Pennsylvania, 300 feet above the Pittsburg vein, is sometimes a workable bed of three feet. On the connected section of the Kentucky measures, (vol. 3, p. 19,) our No. 15th coal is marked 2 feet 6 inches, and placed just 300 feet from No. 12th.

8th. Above the Waynesburg coal, the Pennsylvania Report mention about 600 feet of measures, with three thin beds of coal; and the same connected section mentioned above marks in Kentucky 200 feet more of upper measures above coal No. 15th, with still three thin beds of coal. The comparative sections at the end of this report will further elucidate this remarkable coincidence.

The detailed characters of the different coal strata above the Anvil Rock Sandstone in Western Kentucky, would, probably, render more evident the identity of the measures. But, till now, there has been no opportunity of studying satisfactorily these upper coal beds, either in

GENERAL SECTION OF UNION COUNTY.— 1 INCH FOR 200 FEET.



Kentucky or in Pennsylvania. In Illinois, near Shawneetown, there is, above the Mahoning Sandstone, two veins of coal, one to two feet thick, in close proximity to each other, overlaid at some distance by a thick bed of limestone. The shales of the lower are apparently *gray metal*, or a shaly sandstone blackened with broken, undiscernible plants, nearly like the shales of No. 6th; the upper coal is covered with black slates and limestone shales, full of shells of peculiar species. As these upper coals are generally too thin to be worked with profit, they are rarely opened.

GENERAL SECTION, SHOWING DISTRIBUTION OF STRATA IN LIVINGSTON, CRITTENDEN, UNION, PART OF HOPKINS, DAVIESS, HANCOCK, OHIO, AND BRECKINRIDGE.

The general sections given here for reference exhibit approximately the place of the coal beds of each county. The distance between the veins of coal is of course somewhat variable in each locality, at least for a few feet. When they differ much from those marked in the section, they are mentioned or given in local sections. The abbreviations, C. for coal, S. S. for sandstone, L. for limestone, will be easily understood.

LIVINGSTON COUNTY.

An upheaval of the lower measures has separated in this county a spur of the western coal basin. Coal 1 B is the only vein found in this isolated basin. It is worked at Union mines 3 to 4 feet thick. The palæontological description of this coal bank was given, (vol. 3, p. 531.)

UNION COUNTY, AND PART OF CRITTENDEN.

Coal 1 *B*. The various openings of this vein were lately re-examined along the Tradewater river, on the edges of the measures. At Bell's mines, Crittenden county, it is five feet thick. At Casey's mines, on the west side of Tradewater river, Union county, five feet. Above Caseyville, near the old distillery, two to three feet. It is of the same thickness on the land of the Kentucky Coal Company, one mile and a half north of Caseyville. This review confirms the palæontological characters exposed in the former Report.

Another bed of coal, in the vicinity of Caseyville, was mentioned to me by Dr. B. M. Long, as the Trapnel coal bank, three feet thick at the entry, and supposed to be lower than coal 1 B, from this fact: *that it is underlaid by a single stratum of sandstone about* 40 *feet thick, at the base of which the sub-carboniferous limestone is exposed.** I was prevented, by too high water, from approaching this coal. But from Mr. Long's description, I believe it to be the equivalent of Bell's, viz: No. 1 B.

About 50 feet above Bell's mine, a vein of coal two feet thick has been reported before, referable, with doubt, to No. 1 C.

Coal 2*d*. Has not been seen in Union county.

Coal 3*d*. Is marked only by a streak of coal, below the Curlew limestone, near Curlew mines.

Coal 4*th*. Through the kindness of Mr. Wilwerth, one of the directors of the Mulford mines, I was enabled to examine the vein named Curlew coal, of which the geological horizon was still uncertain in the former Report. Although this vein, partly opened under a great bank of coarse, hard sandstone, was not accessible in its whole thickness; the shales and their characteristic fossil plants showed conclusively the identity of this coal with No. 4th. The sandstone overlaying this coal at Curlew is about 50 feet high, and has the structure and the composition of the Mahoning Sandstone. By its own weight, it breaks, as at Pome-

* Dr. B. M. Long, in letter.

roy, in immense blocks, strewn, like picturesque towers, along the base of the hills. The coal, of which the upper part (18 inches thick) only was exposed, has a roof of 4 to 5 feet of gray, micaceous, hard shales, bearing the prints of *Asterophyllites*, *Pecopteris arborescens*, *Neuropteris flexuosa*, and other species characteristic of No. 4th.

The examination of the Curlew coal has proved that the Geiger's vein, described vol. 3, p. 535, is its geological equivalent, and was rightly referred to it.

The Curlew limestone, about 20 feet below the coal at Curlew, is two to three feet thick, full of fossil shells, especially *Encrinites* and *Terebratulæ*.

Coals 5*th*, 6*th*, 7*th*. Nothing more has been observed in regard to these coals than what has been already reported.

Coal 8*th*. Is not formed in Union county.

Coal 9*th*. Nothing new was elicited by re-examination of the openings of this vein.

Coal 10*th*. Has been recently opened near Mulford three feet thick, rusted by oxide of iron. It has a large proportion of sulphuret of iron, which causes it to decompose under atmospheric influences. Its local characters are exactly the same as described in the former Report.

Coal 11*th*. This vein has been again examined.

1st. On the land of the Curlew company, where it is finely opened, it is separated from the Anvil Rock Sandstone only by six feet of black slates, abundantly filled with the shells of this coal, and a black band six inches thick, which indicates the place of No. 12th. The coal is two feet and a half thick, of fine, bird-eye cannel, and at the bottom six inches of bituminous coal, separated by a clay parting.

2d. At Uniontown, in the Highland mines, where the coal is worked by a shaft 150 feet deep, the black roof slates are like those of the former coal, covered with a great number of the characteristic shells. The coal is five to five and a half feet thick, with a parting of a few inches. In some part of the mines it is covered by six inches to one foot of cannel.

3d. One mile and a half northwest of Morgansfield, on Mr. Thier's property, there are two unopened outcrops of the same coal, covered at both places with flinty limestone.

Though Union county is rich in coal, it derives the greatest advan-

tage from its mines by their proximity to the Ohio river. Along the Tradewater river coal 1 B is already extensively worked. Other outcrops of the same vein will probably soon be discovered in the neighborhood. Above Caseyville, No. 9th and 11th have, for a long time, furnished to the trade of Ohio a large quantity of excellent coal. At Uniontown, coal 11th is worked close to the Ohio river, and from the indications of the borings, the same coal, five feet thick, can be found all around that part of the country. Should the combustible mineral become scarce and more valuable, shafts, sunk from 80 to 100 feet deeper, will descend to No. 9th, which is generally thicker, and has a coal of better quality. Moreover, the detailed Geological Survey of Union county shows, in the interior of the county, numerous outcrops of coal banks, which will be opened and worked as soon as the value of the combustible is equal to the cost of the transportation.

HOPKINS COUNTY.

This county has in store for the future by far the greatest provision of coal of the western basin. Its wealth in this mineral is truly beyond computation. All the veins, from No. 3d to No. 12th, generally well developed, extend nearly over the whole area of this county, and all the outcrops are of easy access. No. 9th and 11th especially, crops out on the slopes of the hills, or descend, by gentle undulations, to the bottom of the valleys, where they are sometimes exposed for long distances in the cuts of the creeks. The town of Providence lies at the top of one of those hills, around which three veins of coal, each from five to six feet thick, are exposed in scarcely 125 feet of measures. In the southeastern part of the county, the waters of Clear, Lamb, Richland, Steward, Caney, Pond creeks, and their numerous tributaries, seem to run for no other purpose than to expose thick coal banks along their course, and to prepare gentle and easy slopes for the mining and transportation of the mineral. In the same vicinity there is an agglomeration of small mountains. Dozier's and Buffalo mountains, Wright's ridge, Bear Wallow, &c., which, from the base to the top, look like a succession of coal, iron, and limestone strata, heaped there as an inducement to labor and industry.

The Henderson and Nashville railroad is traced across the richest part of this coal region. And another projected railroad, to unite Greenville with Caseyville, passes through Mitchel's old field, the sulphur springs

of Mr. Town, and Providence. This road, if ever opened, will run between nearly continuous coal banks. It is a pity that speculation can not be directed at will to constructions which are of so much importance to the country. Until these railroads are built, a mineral wealth of more real value than all the gold of California must lie dormant in the heart of a fertile county, from want of easy communications.

My first exploration in Hopkins county being hurried, I only had an opportunity of seeing a few outcrops, or openings, of its coal banks. The last one was made under more favorable circumstances, with better opportunity for a methodical examination.*

Coal 4th. Its northern outcrops, in Hopkins county, is on the middle prong of Richland creek, on the land of Mr. Ed. Wright; coal two to three feet thick, roofed with a few inches of shales and 12 feet of Mahoning Sandstone. Both shales and sandstone show the characters enumerated before. The same coal is seen in a well at Mr. Rich. Wright's, half a mile west of Wright's ridge. The openings into this vein, south of this place, in Hopkins county, are reported with the Muhlenburg section.

Coal 5th. On Richland creek, middle fork, about half a mile above the former bank, on the same property, coal five feet thick, roofed by 12 feet of black shales, without fossils.

Coal 6th. The coal bank of Mr. Saml. Williams, near the line of Christian county, is referable to this. The coal was covered when I examined it. Its shales have the broken plants which characterize this vein.

Coal 7th has been seen—

At Isinglass glade one foot thick, covered with black, soft, brittle shales, overlaid by a thick stratum of rich carbonate of iron, mixed or alternating with the shales. (Section, by Mr. Lyon, vol. 2, p. 326.)

At Mr. Jas. Skinner's, six miles west of Providence, the vein is three feet thick, about five feet from the surface, 70 feet from No. 9, opened near by. The few shales seen have the characters of this vein. On the same property, coal has been reached 15 feet from the surface; thickness

* Mr. John Wilson had the kindness to show me, around Providence, the openings of coal, in a circuit of from six to ten miles. From Providence to the southern edges of the coal fields in Christian county, my explorations were made in the company of Mr. A. Town, the best informed gentleman on coal localities in the county. From him I received valuable information, constant assistance, and generous hospitality. I am glad to find an opportunity of acknowledging the obligations that the Geological Survey of Hopkins county has received from him.

not reported. It was covered when I visited the place. This is probably the equivalent of the former.

At 'Squire Waugham's, in a well 15 feet below the surface, and 75 feet from No. 9th, opened in the hills, there is a coal said to be three feet thick.

Coal 8th. The false black band, of Hopkins county, has already been mentioned many times in the Reports, (vol. 1, p. 125, vol. 2, pp. 339 and 344, &c.) It is omitted in the connected section of vol. 3, p. 20; it has been examined:

In three openings on Mitchel's heirs property, on Flat creek, where it has only black bituminous slates and thin limestone.

At Mrs. Bradley's, on the same creek, where it is exposed at three places. It has here the black slates only; no black limestone.

On a branch of Steward's creek, on the land of the Hopkins and Mastodon company, it is also opened in three different places, associated with limestone, and very black and very bituminous slates.

About 700 yards from Mr. Town's black band, on Pleasant run, and at Town and Kirkwood, on Sugar creek, it is finely developed with a thin coal.

On the head waters of Richland creek, same property, it has four feet of black limestone, separated by two feet of bituminous slate from another bank of limestone two feet thick.

On Steward creek, same property, three fourths of a mile northwest of Mr. A. Town's house, at two openings of it, limestone and black slates are exposed.

On Cane run, on the land of Mr. John Davis, very bituminous shales, approaching cannel coal, are seen, with thin layers of pyritiferous shales, alternating with bituminous coal. These beds have the general appearance of No. 11th.

On the head waters of Richland creek, a fine bed, apparently cannel, is seen in the creek, on the land of Mr. John Davis. By its palæontology, it is referable to this vein; but the top shales only are visible, and I am not certain of its place.

Coal 9th. It is in Hopkins county, as in Union county, the best and the thickest coal, and the one having the greatest area in this country. Some of its outcrops, or openings, are already reported, vol. 3. Its short distance from the surface (70 to 75 feet in Hopkins) renders it

accessible by shafts at a number of localities where No. 11th is placed at the middle, or the base of the hills. It has been examined:

In a well at Mr. John Wilson's, two and a half miles from Providence, three feet thick. This is probably the coal marked, on the map of Hopkins, as 'Squire Little's coal.

At Mr. Jas. Skinner's it is well exposed; coal five feet thick, very fine, without parting, but with a roof of six feet of black shales.

At 'Squire Waugham's it is four feet thick, without any parting, covered by three feet of black shales. Both this and the former have the characteristic fossils in abundance. Mr. Waugham has many openings of this coal, of the same thickness, in the hills around.

At Wynn's entry, southwest of Providence, near Montezuma, this coal is four feet thick, with 10 to 12 feet of black shales above it, and exhibits the same characters as the former. This coal has been referred to a low coal; but the presence of remains of fishes, and of shells of identical species with those of No. 9th, is at variance with this conclusion. The sandstone capping the hills near Montezuma is the Anvil Rock Sandstone.

At Hunter's bank, one mile south of Providence, on Owen's creek, coal is reported in the section given vol. 3, p. 120.

Montgomery's coal bank, one mile southwest of Providence, is reported with the former. Both are well characterized by their shales and fossils.

South of Providence, coal 9th is opened at Mr. John Davis', near his residence, five feet thick, without any clay parting. It also crops out half a mile further, near the base of the hills, in a position somewhat lower than the former. The bank appears to have been displaced by a slide of the underlaying fire clay, softened by a running spring. The coal is covered.

At Mr. Jas. Kirkwood's, one mile from the former, it is four feet thick.

At Mr. Henson's, one fourth of a mile from Lamb creek, there are two outcrops of coal, said to be six feet thick, without a parting. They are referred, with doubt, to No. 9th. I could see only a few pieces of shales, the coal being covered up from view.

Mr. Wm. Davis' coal, in a well on Lamb creek, judging from the shales found around the well, is evidently coal No. 9th.

At Woodson and Godwin's coal bank, head waters of Richland creek, it is beautifully exposed, five and a half feet thick, without clay parting, and is covered by a thick stratum of black shales.

At Butt's gap, this coal is five feet eight inches thick, on the property of Mr. A. Town. It has some pyritiferous limestone in the fire clay at its bottom.

On the land of the Hopkins Mastodon company, south of the railroad tunnel, near the base of the hills, the same coal is five feet thick without any parting.

The coal in a well at Mr. John A. Exell's, 17 feet from the surface, between Pleasant run and Crab Orchard, head waters of Caney, belongs probably to No. 9th; but I could not see the shales.

On the property of Mr. A. Town, peak of Otter, this coal is five feet four inches, without a parting.

On the same property, Box mountain, it is six feet thick, without a parting.

At the foot of Dozier's mountain, near Fox run, Mrs. Nancy Morgan's coal bank is four feet thick, without a parting.

On the waters of the Caney, at Mr. R. Woodruff's, this coal is now covered; it has been previously worked, and is reported four feet thick. I have only seen the shales.

On the same creek, at Mr. Harrell's, it is beautifully exposed, (8 feet thick.) It has here, as at both the above mentioned places, a fine bed of carbonate of iron, in blue shales, overlaying its roof slates, and a fine mineral spring issues from the bottom of the coal. This carbonate of iron is generally found at the same horizon in Hopkins county. It is especially rich and abundant at Wright's ridge and Buffalo Mount, on the land of Messrs. Town and Kirkwood.

On Steward's creek, near the natural bridge of Mr. A. Town, coal 9th is seen at two openings, and is 6½ feet thick. Although these banks are nearer to the base of the Anvil Rock Sandstone than usual, viz: distant only from 40 to 50 feet, they are referable to No. 9th by their shales. The coal has no clay parting.

It is hardly necessary to mention other obscure outcrops of this vein, which could not be satisfactorily examined.

Coal 10th. On the Hopkins and Mastodon company's land, south of the tunnel, this coal is said to be 4 feet thick. I could not see it.

Neither could I find a single well ascertained outcrop of it in the numerous localities where Nos. 9th and 11th were exposed on the same hills. If it exists in Hopkins county, it is probably a thin coal, hardly recognized in a country where such extensive veins as No. 9th and No. 11th are everywhere found.

Coal 11*th*. Was examined again at Watson's and Llwellyn's coal banks, reported, with section, vol. 2, pp. 316–7, and vol. 1, p. 398. From palæontological evidence both banks belong evidently to this vein. In the 7 feet 8 inches space of the section, below the limestone, there may be a streak of coal No. 10th; but I could see nothing of it. In the Holloway's boring such a streak, 10 inches thick, is found at the same place. The limestone above No. 11th is, at Watson's, as generally, in irregular, loose pieces; sometimes of a great size, or in a continuous bank; sometimes in loose blocks, no larger than a man's head.

At and around Providence, coal 11th was examined—

At Hunter's bank, half a mile north of Providence. Here, however, it is half concealed from view by debris. It has limestone above it.

At E. Dorris', three miles north of the town, it is 5 feet thick, with 2 inches of clay parting, and with limestone above it.

At Mr. James Johnson's, 3 miles northwest of Providence, this coal is also 5 feet thick, with 3 to 5 inches of clay parting, and with limestone above it. The fire clay of the bottom is here full of crystals of gypsum. The iron sandstone, or base of the Anvil Rock, is 20 feet above the coal.

Lofland's coal bank, opened just behind the hill of Providence, is covered with a limestone only for a short distance within the entry, like the Clark's Mill coal. At the entry the section is:

	Feet.	Inches.
Shaly sandstone, (covered space)	10	--------
Limestone in irregular banks	1	3
Black bituminous shales	2	3
Brashy bituminous coal	--------	9
Clay parting	--------	1
Bituminous coal, with 3 inches clay parting	4	8
Fire clay to level of creek	2	--------

Mr. Lyon's section of this bank, (vol. 2, p. 319,) was taken at some other point.

At Dorris bank, coal 11th has the same irregular limestone, and the same distribution of coal and shales. Some pieces of the limestone are imbedded in a soft, grayish fire clay, and insensibly pass to a continuous bank. Where the limestone is not present, there is above the argillaceous clay a streak of 3 inches of black shales, probably of No. 12th.

Close to the Madisonville road, at Providence, it is worked at three different openings, with this association:

	Feet.
Covered space, shales and sandstone	20
Limestone in bank	2
Coal, with 3 inches clay parting	6
Fire clay	3

Below this fire clay, which is sometimes 4 feet thick, there is no trace of yellow limestone. The limestone of the roof of these banks can be followed in its irregularities to Lofland's and Dorris' banks. That those coal banks at Providence are the equivalents of Llwellyn's and Watson's banks, is put beyond question by the remarkable idenity of fossil remains and the nature and composition of the shales.

At Bruce's Mill, three and a half miles east of Providence, a coal is worked, 18 to 20 inches thick, 7 feet below the surface. Near by, it has been struck 6 feet thick. It is entirely covered, and therefore I refer it with doubt to No. 11th.

At Mr. Hiram Kirkwood's, one half mile west of Mr. John Davis', are two outcrops of the same No. 11. The limestone above it is 6 to 8 feet thick. The coal is not seen; but near by, on the level with the outcrops, a bed of ochreous iron ore identifies the place. The top of the hills, at Mr. John Davis', is formed by 15 feet limestone overlaid at a short distance by 6 to 10 feet of shales, and then by 25 to 40 feet of the Anvil Rock Sandstone. This sandstone is here hard, coarse, weathered near the base in irregular holes and protruding bands, hardened by oxide of iron, just like the millstone grit at Caseyville, and the Mahoning Sandstone at Curlew and Pomeroy. Indeed, these three great sandstones have generally the same external appearance, and could scarcely be distinguished, if it was not from the nature and the place of the coal banks which they overlay.

At Mr. Randal Davis', about 500 yards northeast of Lamb creek, and one half mile south of Richland creek, this coal is 5 to 6 feet thick, with 9 inches clay parting, and no limestone above it. The base of the Anvil Rock Sandstone is 50 feet above the coal.

At Mr. John Davis', head waters of Lamb creek, one half mile southeast of the former, this coal is reported covered; the bed is now concealed from view. The shales have the fossils of this vein, and it has above it, also, the ochreous iron ore which generally overlays No. 11th in this part of the county. No. 12th is here 6 feet higher.

At Mr. B. Lafoon's, the red ochreous iron ore of No. 11th is 2 to 3 feet thick, and very rich; the coal appears to be absent here.

At Butts' gap, Davis' branch, on the land of the Hopkins and Mastodon company, this coal is 4 feet thick, and only 20 feet below the base of the Anvil Rock Sandstone. It has ochreous iron ore above it here also.

On the property of Henderson Seminary, at Barney's ridge, No. 11th coal crops out in close proximity to No. 12th, 25 feet below the base of the Anvil Rock Sandstone. Both veins are separated by 10 feet of the black shales of No. 11. No limestone is present in the hill; but the ochreous iron ore occupies its place.

On Price's and Johnson's land, near Rocky gap, No. 11th and 12th veins are in connection, 10 to 11 feet thick, with two clay partings. Behind the hill, the upper clay parting thickens to 6 feet, and thus both coal beds are distinct.

At a short distance from this bank, on the same property, there is a bed of cannel coal, said to be 4 feet thick, overlaid by 2 feet 9 inches of bituminous coal. It is referable to No. 11th by the fossil shells of its slates. It has above it some black band or ferruginous limestone. The appearance of this bank is different from the former and much like the cannel coal No. 11th, at Curlew. The bituminous roof shales are full of the same shells. Around Providence this vein has sometimes a few inches of cannel and the same appearance. The identification of this coal with No. 11th is from palæontological evidence more certain than that of the former, which has scarcely any fossils, and which might belong to No. 12th, in an anormal state of development.

Arnold's bank, east fork of Steward creek, has been reported, and is mentioned only because, in examining it again, the limestone was found above it. It has generally two clay partings, and is now worked 8 feet thick. It is opened also at Mr. Bart Sisk's.

On Gamblin's land, on branch of Steward creek, this coal is scarcely opened so as to be seen, but has the drab-colored limestone below.

On northwest spur of Wright's ridge it shows itself, and all around the same hill, as well as on Buffalo Mount, on the property of Messrs. Town and Kirkwood, with yellow limestone below; but the exposure is only partial.

On the same land, at the head waters of Richland, this coal is 5 feet thick, with drab-colored limestone below and ochreous limestone above. It lies here 80 feet above the false black band.

On Box Mount, near Copperas Springs, Town's and Kirkwood's property, it is 6 feet thick, with ochreous iron ore above it.

Other expositions of this vein, so abundantly distributed in Hopkins county, are reported, vol. 3, pp. 546–7. Many more could have been mentioned, but for the impossibility of examining the shales, and thus identifying their palæontological characters.

Coal 12th. In its separate state from No. 11th, and with its proper characters, has been seen:

At Hunter's so-called black band, one mile north of Providence, where it is separated from Dorris' bank by limestone and shales; the coal is 3 feet thick, shaly, overlaid by some black band iron ore and bituminous cannel shales, full of stigmaria.

At Herrin's, half mile east of Providence, this coal is said to be 6 feet thick, mostly shales, with some poor coal, covered in part.

On the head waters of Lamb creek, at Mr. John Davis', it is not opened. This and the outcrop on Henderson Seminary land are mentioned with No. 11th.

At Burk Earl's bank, between Rocky Gap and Caney creek, coal brashy, roof shales very bituminous, full of stigmaria and stems.

At Town's and Kirkwood's, top of Buffalo Mount, said to be 30 feet above No. 11th, it is scarcely opened.

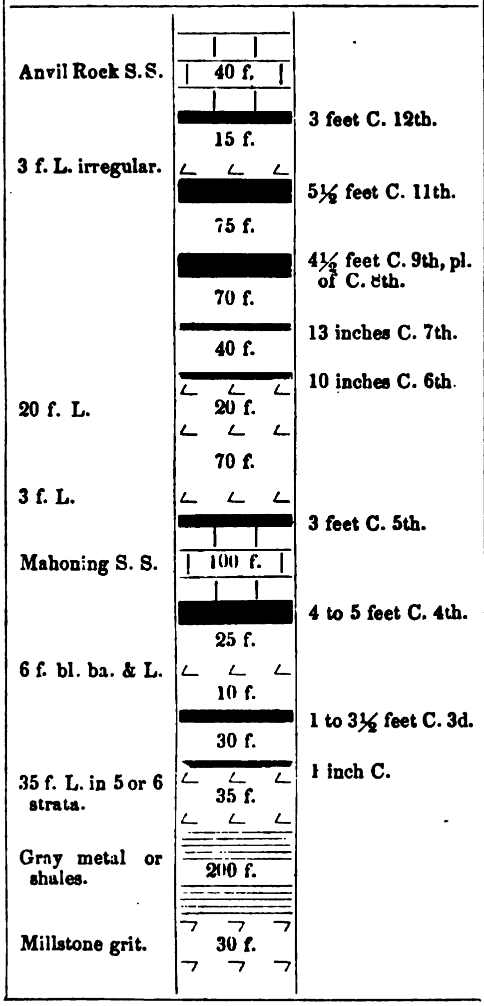
The Box Mount upper coal, and the upper coal near the Copperas Springs, on the property of Messrs. Town and Kirkwood, belong, from their position above No. 11th, to this vein. But they are, as yet, unopened.

DAVIESS, HANCOCK, OHIO, AND BRECKINRIDGE COUNTIES.

Except the coal banks along Green river, which are reported with the Muhlenburg section, no other coal banks have been examined in these counties but those reported in the 3d volume. A few have been again visited without eliciting any new facts worth recording. Only at Bon

Harbor the re-examination showed, above the vein of coal, an irregular bed of limestone, underlaying a streak of 12th coal. The hills around are topped by the Mahoning Sandstone.

GENERAL SECTION OF MUHLENBURG CO.



MUHLENBURG, PART OF HOPKINS, CHRISTIAN, AND BUTLER COUNTIES.

This section presents a remarkable difference from the former. The lowest coal, No. 1, with its divisions, and No. 2, are entirely wanting. Coal 3d is formed under a limestone sometimes containing a rich black band iron ore. Thirty feet below it, there is one inch coal, and then 6 or 8 feet of strata of limestone, in layers of from 3 to 4 feet thick, underlaid by about 200 feet of gray micaceous shales or *gray metal*, to the top of the conglomerate or *millstone grit.*

Though our veins Nos. 3 and 4 have such a peculiar palæontology, that it was not possible to mistake their characters, I would not admit as positive the total disappeaaance of both the lower coal beds, until I had followed the distribution of the measures along their southern edges, in Christian county, and especially spent in careful examination of south Hopkins county and Muhlenburg county, as much time as was necessary to elucidate the question by stratigraphical evidence. This evidence confirmed the conclusions drawn from palæontology, proving: that from the mouth of Caney creek, in the Tradewater river, along the southern edge of the basin, across Christian, Muhlenburg, and Butler

counties, as far as Morgantown, the only two workable coal strata are No. 3d and No. 4th, in close proximity.

Both the coal banks of Mr. Drue Wooldridge and of Mr. Larkin Campbell are acknowledged to be, in Christian county, the lowest beds, except, perhaps, a streak of coal reported by Mr. Campbell as cropping out in Casselbury creek, one mile south of his house. These two beds of coal are separated at both places by about 20 feet of measures, containing a limestone which varies in thickness from a few inches to 4 feet. At Mrs. E. Brasher's coal bank, on the same horizon as the lowest coal of Mr. Campbell, the limestone is partly replaced by a ferruginous chocolate-colored black band iron ore, identical with the Black-band of the old Pennsylvania furnace, in Muhlenburg county. The color, nature, composition, palæontology of that *band* is so peculiar, that it is not possible to mistake it for any other stratum. Moreover, it can be traced all along from Christian county to Muhlenburg county, where it is now opened in many places. At the old Pennsylvania furnace the distribution of the measures below the black band can be very easily followed on the back of an anticlinal structure, which has brought up the sub-carboniferous members, and exposed the lower measures down from the Mahoning Sandstone. From No. 3d, except a streak of a few inches, there is no trace of coal to the conglomerate.

If more conclusive evidence was wanted, numerous borings were made in the vicinity by Mr. Alex. Hendrie, when the furnace was in activity, and recently further west, on the land of Mr. Alexander. By these borings the nature of the measures has been ascertained for more than 300 feet below the black band. It is only limestone and gray metal to the millstone grit; and no trace of coal has ever been found in the space but the one inch vein already mentioned. It is probably the equivalent of the thin vein of coal seen in Casselbury creek by Mr. Campbell.

The first coal above the black band, or the upper Wooldridge coal, is covered by a bank of hard, somewhat conglomeratic, coarse sandstone, containing plants transformed into charcoal, (the Mahoning Sandstone.) This sandstone is thin at Mr. Wooldridge's, but increases in thickness to the north, along the old Buttermilk road. At Mr. G. Terry's, on branch of Buffalo creek, it is already 30 feet. At Mr. Roland Williams' it forms, above the coal, a bluff of about 40 feet. It is seen, as reported before, with the same characters, near the foot of Wright's ridge, over-

laying 3 feet of coal, and upon it are piled up the measures of the ridge, which can be followed to the Anvil Rock Sandstone, which caps the ridge.

On Mr. Alexander's land, near the old Pennsylvania furnace, borings were made from the top of the Mahoning Sandstone to the black band, which was reached 20 to 25 feet below No. 4th coal, just underlaying the Mahoning Sandstone, which is here 76 feet thick; and the measures, from the boring, or even from the base of the sandstone, can likewise be followed in exposed stratification, at and around Greenville, up to the Anvil Rock. Though it is probable that at Messrs. Wooldridge and Campbell's, coals No. 3d and No. 4th come nearer to the sub-carboniferous measures than at the old Pennsylvania furnace, yet these coals, even if they were not so positively identified by palæontology and stratigraphy, could not be mistaken for any of the lowest veins, which are never accompanied by such strata as the limestone above the 3d vein, and the hard, thick, conglomeratic sandstone above the 4th.

The upper division of the measures, as marked in the section, is, like the lower, elicited by a series of borings and of stratigraphical observations. It gives thus a true representation of the upper coal measures in the southwestern part of the western coal basin. Except that the strata are somewhat reduced, and that two banks of shales and sandstone are replaced by limestone, the distribution is about the same as marked on the section of Union county. The two banks of limestone placed in Muhlenburg county, between 5th and 6th coals, are very variable in their distribution. The upper one attains its greatest development at Greenville, thins to the northwest, being at Airdrie 4 feet only. At Vallandingham's it is in two parts, one and two feet thick, separated by 5 feet of fire clay. The lower limestone, marked on the section just above coal 5th, is generally replaced south of Greenville by a bed of carbonate of iron. But it is formed at Airdrie 1½ foot thick.

Muhlenburg county shows in its geological distribution some analogy to Greenup county, viz: a thinning out of the measures by the appearance of limestone beds and iron ore, which take the place of great banks of sandstone developed elsewhere. As this metamorphosis is still more marked and defined in Greenup, it will be examined in discussing the general section of that county.

Coal 3d. In its last exposure to the south, it is so near the surface

that it is worked by stripping. The roof shales, grayish, soft, easily broken, contain at Mr. Larkin Campbell's and at Mr. Woolridge's a great quantity of the stems and leaves of this vein. The upper part of the shales is chocolate colored, very hard, and shows the first appearance of the black band.

It was examined also: At Mrs. Aquila Brasher's, where it comes to 2 feet from the surface, and is 2½ feet thick. The gray shales are pulverized by infiltration and atmospheric influence.

At Mr. G. Terry's, half a mile southwest of Mr. Waugham's entry, on Buffalo branch, the partially opened coal is 2 feet thick. It is also in the creek 25 feet lower than Mr. Waugham's coal bank.

It is probable that the coal bank of Mr. Archibald Bourland belongs to this vein; but it is covered, and could not be examined.

Near the old Pennsylvania furnace this coal is only 1 to 2 feet thick. At one place it ascends by a curve to No. 4th, and near the point of junction both beds of coal disappear, and are replaced by a bed of carbonate of iron.

Coal 3d has been found many times by borings on the land of Mr. Alexander, always from 20 to 30 feet lower than No. 4th. About one mile southwest of the old furnace, it is beautifully exposed with the black band, as follows:

	Feet.	Inches.
Sandstone passing into gray metal	8	7
Carbonate of iron and soft shales	3	--------
Black, soft, brittle shales, with Lepidodendron	--------	8
Black band iron ore	--------	10
Black, soft shales, with plants	6	--------
Coal, (bituminous)	2	6

At Williams' landing, on Green river, the black band, says Mr. A. Hendric, is below 2 feet 6 inches of black slates, and a bed of coal is placed 33 feet lower. On the Williams section, vol 1, p. 143 of the Reports, the coal brash, 2 feet 6 inches, is placed below the black band, and, following the same authority, it ought to be placed above.

Coal 4th. Has been examined—

At Drue Wooldridge's and Larkin Campbell's upper coal banks. The excellent quality of this 4th coal is remarked every where it has been worked. At both the openings it is three feet thick:

At T. and T. W. Waugham's, 1 mile west of Terry's entry, on Buffalo creek, where the coal is 4½ feet thick. The shales above it are covered with the characteristic plants of this vein:

At G. Terry's coal bank, near the Buttermilk road, 1 mile from his house, on Buffalo creek, the coal is 4½ feet thick at two openings, covered with shales and sandstone:

At Mr. Roland Williams', half a mile west of the former, the same coal is opened under a high bank of sandstone. It is roofed by the shales with plants:

At Widow Humphrey's, 3 miles southeast of Greenville, this coal is not well exposed, and said to be 3½ feet thick. It is referable to this vein from the Mahoning Sandstone seen above it.

On Mr. Alexander's land, about 4 miles southwest of Greenville, some four to six openings of this coal, 4 to 5 feet thick, mostly without shales, are overlaid by the Mahoning Sandstone. The Eade's coal, 2 miles distant, has above it the fossiliferous shales, like Terry's and Williams' coal banks. At Mr. W. Evans', it is 4 feet thick, just under sandstone. It has been reported above as the coal worked for coke for the old Pennsylvania furnace.

This vein is crossed in Williams' boring, on Green river, under 36 feet of sandstone. In the Airdrie shaft, it is probably only a coal streak below a sandstone 23 feet thick, and in this case the black band would be marked by black slate and iron stone, with two thin coals, at 130½ feet of the boring. This boring completing the section, vol. 3, p. 24, from the base of the shaft, is as follows:

	Feet.	Inches.
Shales, blaes,* and sand rock	9	9½
Gray micaceous shales, gray metal, &c.	17	5¼
Hard rock	5	7
Soft sandstone rock	2	5
Sandstone	18	9
Gray micaceous shales, (fakey and blaes)	11	10¾
Sandstone	3	8¾
Gray shales	1	5
Sand rock and shaly sandstone	17	8¾
Hard rib	--------	3
Coal streak	--------	1¼
Sandstone	5	4¾
Shales, gray metal, and blaes	31	10⅛
Black slate, black band?	3	4⅜
Iron stone, black band?	--------	5¾
Coal, divided by a streak of sulphuret of iron	1	6
Sandstone and shales	9	--------
Balls	--------	9
Gray metal and shaly sandstone	27	10¼
Alternating iron balls and shales	19	7¾
Coal	--------	5
Gray metal and shales	26	10
From base of shaft, 216 feet.		

* Term used by the English miners. Like fakey, it indicates a schistose clay, or clay shales.

Coal 5th. Is placed at Greenville, near the top of the Mahoning Sandstone, at the base of the great limestone. It is seen 1 mile from the town, on the Hopkinsville road, where the shales only are exposed.

At Mr. Robertson's coal bank, 3 miles south of Greenville, it is 18 inches thick, with 5 to 6 feet black shales above it.

Coal 6th. It crops out at Greenville, just at the top of the limestone, with its peculiar micaceous gray shales, blackened with broken plants. It was found also in Mr. Short's well, at 45 feet from the surface. Near the old Pennsylvania furnace, it is exposed 6 to 10 inches thick in the same gray metal.

From the nature of the shales and broken plants, I refer to this vein Mr. E. S. John's coal, near the Buttermilk road, Hopkins county. The coal is about 4 feet thick, very good for blacksmithing, and is opened at two places on the same property. It is probably the coal cropping out in the bed of Caney creek, one mile northwest of Greenville, where it is 13 inches thick. The bed of coal at the Vallandingham boring, 3 feet 6 inches thick, below black shales, at 50 feet from the surface, is also referable to No. 6th.

Coal 7th. Was passed at Greenville, in Mr. Short's boring, about

25 feet above the former. It crops out also near the old Pennsylvania furnace, 40 feet above the limestone, but is only a few inches thick.

Coal 8th. Or false black band, was seen only in Muhlenburg county, as reported before, at Mr. E. B. Veirs', where it has only black shales and a few septaria. There is an abundance of shells and fish remains in the shales.

Coal 9th. About 3 miles northwest of Greenville, it is finely exposed on Messrs. Veirs & Rickett's land, 60 feet below No. 11th coal, 4½ to 5 feet thick, without clay parting. No trace of No. 10th was seen above this vein, nor has it been observed in Muhlenburg county. This 9th coal is also found in the hills, 20 feet above No. 8th, at Mr. E. R. Veirs'.

At Vallandingham's, on Green river, it is only one foot thick, 50 feet below 11th.

At Lewisport boring, it is found six feet ten inches thick.

At and around South Carrollton, it is not formed.

At Taylor's mines, below Cromwell, it is 50 feet below the main coal No. 11, with its characteristic shales well developed. Coal 3 feet thick.

At Mr. Cook's mines, above Livermore, Ohio county, the same No. 9 is found 50 feet below No. 11, where it has been reached by a shaft, and is 5 feet thick.

Coals 11th and 12th. Outcrop on Veirs and Rickett's, with 15 feet of distance between both. Some boulders of limestone appear above No. 11th.

Coal 11th is worked near by at Mr. Hugh H. Martin's, 3 miles northwest of Greenville, 5½ feet thick, with two clay partings. It is roofed with a limestone 2 to 3 feet thick. Coal 12th is seen in the hills above No. 11th, but thin.

At Mr. Th. Withers' outcrops, and at Mr. Andrew Glenn's, on the road from Greenville to Paradise, coal No. 11th is 4 feet thick. At Mr. Glenn's it is opened and has above it some boulders of limestone, with abundance of shells. Near by, the limestone is replaced by the ochreous iron ore of Hopkins county. In Mr. Glenn's well coal No. 9th was reached 50 feet below No. 11th.

Both 11th and 12th veins have already been reported at Airdrie, where the ochreous iron ore is also found, sometimes at the place of the limestone above No. 11th; and also at Clark's mill.

At Vallandingham's coal 12th is seen near the top of the hills, with its black band, and No. 11th is opened 15 feet below it, and has a roof of limestone.

At South Carrollton, No. 12th is also formed 2 feet thick, with iron stone above it, and No. 11th is 30 feet lower, apparently cannel.

At Taylor's mines No. 11th is 4½ feet thick, just at the base of the Anvil Rock Sandstone. It is covered by two feet of its black, crumbling shales, with abundance of shells. No. 12th is marked in the sandstone by a streak of coal 6 feet above No. 11th.

The Rough creek coal mines of Mr. Cook, as also the Eberly coal mines in the ridge on the other side of Green river, belong to No. 11. At Mr. Cook's the coal is about 35 feet below the Anvil Rock Sandstone, and at Eberly's ridge this sandstone covers the shale of the coal as at Taylor's mines.

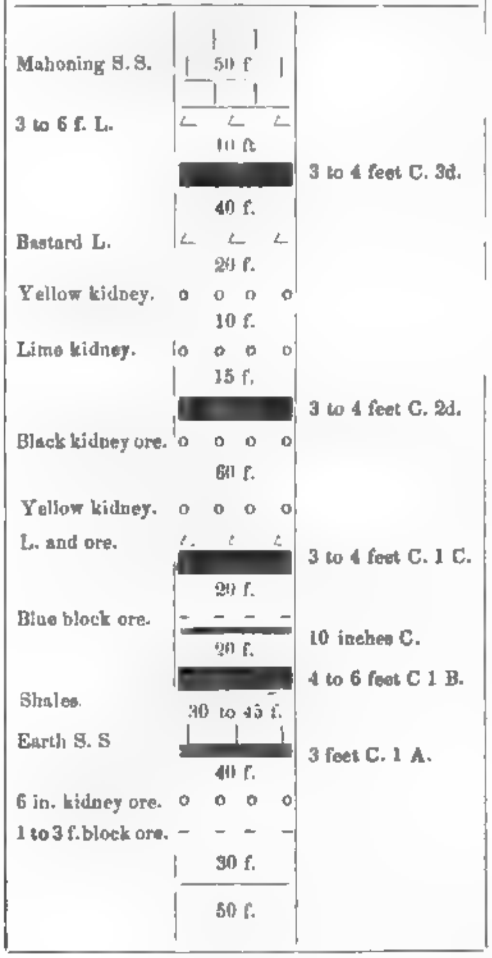
At Cook's mines the coal is 4½ to 5 feet thick, overlaid by a roof of cannel shales, and some small boulders of limestone, or rather of septaria. On both sides of the river the shales have abundance of their characteristic fossils, and the coal has a tendency to cannel. Mr. Cook has opened his vein at three different places, and found it of the same quality and thickness. The top of the Anvil Rock Sandstone, near one of the openings, is covered by a fossiliferous gray limestone.

It is not possible to make a just appreciation of the mineral wealth of Muhlenburg, Daviess, and Ohio counties. The difficulty of profitably using or transporting the rough material dampens the interest of the proprietors, and prevents careful researches. It is only along Green river that the coal has been worked with some activity, and the great amount of coal and iron ores recorded in the shaft and boring of Airdrie is a fair indication of what may be found in the interior of those counties.

GREENUP AND CARTER COUNTIES.

Greenup county deserves the first place in the whole State of Kentucky for its mineral wealth. It has, in abundance, beds of iron ore of excellent quality, thick veins of fat cannel coal; and, with this, a most favorable position along the Ohio river, which facilitates the transportation of the produces of its mines, already transformed by its numerous furnaces and oil factories. It would be pleasant to dwell on the prospects of future prosperity offered to such a county by the increase of an industrious population. But the task of the Geologist is to find out, to

GENERAL SECTION FOR GREENUP AND CARTER COUNTIES—1 INCH FOR 100 FEET.



examine, not to follow those springs of wealth, which industry only knows how to guide and to regulate for the best advantage of a country.

The formation of the numerous veins of iron ore which cover the whole extent of Greenup county, the northern part of Carter, in Kentucky, with the south of Scioto county, in Ohio, is a geological problem of the greatest interest. It has been supposed that those deposits of iron ore are due to the agency of marine currents, acting along a shore, and transporting the materials from a distance. But all the veins of iron of Greenup county indicate a quiet deposit, and do not show any trace of disturbance. Numbers of these veins, placed at different horizons, are covered with soft black shales stratified, and, consequently, were deposited in a quiet body of water. Even some of the richest ores are locally intermixed with a quantity of roots of *stigmaria*, of which the leaves are extended in their natural position—a proof that they have never been disturbed by any movement of the water. At the epoch of the formation of the coal, all the country now under examination must have been a lake, an inland lagoon, full of low Islands, covered with the vegetation of the coal marshes. As it happens now in the formation of the bog iron ore around the peat bogs of our formations, the iron was in a process of constant chemical formation and agglomeration around the marshes of the coal epoch, in such places where the water was too deep for the growth

of the plants. In following the distribution of some of the coal beds of Greenup, they are found to run into or lose themselves in beds of iron ore, generally placed somewhat lower than the coal. It is especially the case with coal 1 C.

If the peculiar distribution of the ores and coal strata of Greenup county was general all along the edges of the eastern coal fields of Kentucky and Ohio, it would be perhaps reasonable to draw the conclusion that these shallow marshes or low islands did form the true limits of the eastern coal basin, and consequently that the great Silurian ridge, which separates both coal fields of Illinois and Ohio, was already formed at the coal epoch. But there is no similar formation any where along the edges of the coal basins of Kentucky, (except perhaps a small area in Muhlenburg county,) neither to the south in Morgan, Breathitt, Owsley, nor in Ohio, except adjacent to the Ohio river, opposite Greenup county. On the contrary, iron deposits of the same nature are found in abundance in the centre of the great Apalachian coal basin, where the coal formations are continuous. This is, therefore, a local formation, which has nothing to do with the laws of distribution which have governed the whole.

Contrary to assertions, I find in Greenup county more evidence of the upraising of the coal measures against the Silurian ridge, and consequently a proof of the separation of the great basin by an upheaval posterior to the formation of the coal. Six miles west of Greenupsburg, the sub-carboniferous limestone is exposed at the top of a high hill, about 400 feet above the Ohio river. A strong dip to the east soon brings it at the level of Tygert's creek, where it disappears. At White Oak creek, coal 1 A makes its first appearance in the hills, and crops out at Coal creek, nearly at the high water level of the Ohio river, 2 miles west of Greenupsburg. Henceforth the general dip to the east discontinues, as far at least as the mouth of Big Sandy, and is replaced by gentle undulations, of which the highest point is no more than thirty feet above the general water level of the country.

Greenup county has been, till lately, considered as especially abounding in productive iron ores, but deprived of valuable deposits of coal. The opening of the railroad traversing the county from Ashland to Grayson, and the impetus given to the search for cannel coal, by its use for the fabrication of oil, have caused the discovery of so many new coal banks, that now this county may be regarded not only as possessing

a number of workable coal beds, but as having probably the thickest strata of cannel coal in Kentucky. It is, therefore, convenient to correct a few of the sections formerly given by the addition of the new opened coal banks.

The section at Amanda furnace is one of the most interesting in Greenup county, from the beautiful display of mineral strata, veins of coal, beds of iron ore, of limestone, and of fire clay, which are exposed on the same vertical plan on the hill facing the river behind the furnace. The section is:

	Feet.	Inches.
Top of the hills, covered space	20	
Coarse, soft, ochreous iron ore		10
Coal not opened, C. 3 ?	3	
Covered space, shales and sandstone	26	
Small vein of kidney ore		2
Shales and shaly sandstone	25	
Yellow kidney iron ore		6
Covered space, shales and sandstone	5	
Lime, kidney iron ore		10
Sandstone and yellow shales	17	
Main Amanda coal bank, with clay parting, C. 2	4	
Shales and shaly sandstone	30	
Hard compact sandstone	13	
Gray soft shales	4	
Black soft shales without fossils	2	
Fire clay	2	
Kidney iron ore		3
Alum fire clay	5	5
Limestone ore	3	
Limestone	4	
Slates and shales	20	
Clay	2	6
Slate or kidney ore, with black soft shales		10
Cannel coal, with clay parting, 3 to 4 inches 1 B	5	
Covered space, shales, &c.	18	
Earth, sandstone, and plants	25	
Black shales and Lepidodendron	4	
Bituminous coal, 1 A	2	8
Fire clay	2	
Shales	15	
Black shales, with 2 inches kidney iron ore	18	
Fire clay	2	
Block ore	1	

Space covered to low water of the river about 50 feet.

The section at Chinch creek, between Steam furnace and the Old Fulton forge, shows the distribution of the coal strata in a still more favorable light. It marks the place of the more important strata of Steam furnace, and is as follows:

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	Feet.	Inches.
Top of hills, space covered, sandstone and shales	50 to 75	
Sandstone and shales	8	
Coal, bituminous	1	3
Fire clay	2	
Iron ore	1	
Limestone, irregular, often absent	1	
Shales and sandstone	40	
Kidney slate or top ore of Steam furnace	1	
Space covered	10	
Coal, No. 2d	2	
Shales and slates, No. 2	4	
Coal, No. 2d	2 to 3	
Shales and sandstone	75	
Bituminous slate, No. 1 C	1	
Shales and sandstone	15	
Black slates with Flabellaria, &c., No. 1 B Chinch coal		10
Cannel coal in blocks, No. 1 B Chinch coal	4	4
Black shales and plants, No. 1 B Chinch coal		8
Bituminous coal, No. 1 B Chinch coal		3
Black slate parting, No. 1 B Chinch coal		4
Bituminous coal, No. 1 B Chinch coal		10
Block ore at Steam furnace, where coal B is absent	1	
Sandstone, shales, and gray metal	38	
Coal No. 1 A, 3 feet coal, 1 foot shales above	4	
Covered space, shales, sandstone, and gray metal	60	
Coal or cannel shales		4

At Steam furnace, this last streak of coal is 20 feet below the surface in a well. At Chinch creek, it is just at the level of the creek. Here the distance to the base of No. 1 B is just 100 feet. At Steam furnace, where the coal 1 B is not formed, the distance from this streak of coal to the block ore, or place of No. 1 B, is also 100 feet. Where this block ore is found, the coal is generally absent.

No trace of coal has been seen in Greenup county below the millstone grit or conglomerate. The examination of the coal banks of the county begins, therefore, with No. 1 A.

Coal 1 A seen opened at—

Mr. S. Bradshaw's, near the bed of Indian creek, 3 feet thick, with 6 inches clay parting, and a roof of shales.

At Chinch branch, on the land of the Maysville Coal and Oil Company, where it is 3 feet thick and bituminous, overlaid with sandstone.

Near Steam furnace, at Mr. G. Davidson's, coal 4 feet thick, with one foot clay parting, and a roof of black shales above it.

At Ulin's branch, one and a half miles below Steam furnace, and near by at the head waters of Ramsey hollow. Here the coal, under black shales 2 to 3 feet thick, is now hid by a slide of the bank.

Dr. Spalding's coal, 8 inches thick, covered with the black shales, has the characteristic *Lingula* and *Lepidophilla*. It is exposed on the road from Greenupsburg to Raccoon furnace.

At Raccoon furnace, in the bed of the creek, coal 8 inches thick.

At Coal creek, one mile above its mouth, at Mr. Richards', coal 18 inches thick. The roof is a thick stratum of black shales overlaid by a sandstone, full of plants.

At Mr. W. England's coal bank, on Slash branch, same thickness and characters as the former.

At Caroline furnace, coal 15 feet above the creek, mostly roofed by sandstone, sometimes with one foot of shales. It varies in thickness from 1 foot to 18 inches.

On branch of Oak creek, on the road to Amanda furnace, Hammer's coal, 18 to 24 inches thick, under its sandstone. At this place the coal looks better than at Caroline furnace.

At Amanda furnace, coal 10 to 18 inches, under black shales. It has some coal brash at its bottom.

Around Buena Vista and Greenup furnaces this coal, 8 to 14 inches thick, is seen at some of its outcrops, near the branch of the creek, mostly overlaid by sandstone. At Bush creek it is 2 feet thick.

At Catlettsburg, 25 feet below 1 B, a coal is exposed in a deep ravine, about half a mile east of the town, and, from its position, is referable to this 1st A vein. It appears roofed by fire clay and iron ore, and 6 to 8 inches thick.

From Catlettsburg to Grayson, along the railroad, this coal is not seen; but at Grayson it is exposed on Dr. Lansdown's property, near his house, coal 1 foot thick, 50 feet above low water of Little Sandy, where the top of the millstone grit is exposed. This is the only place where this coal was examined in Carter county.

Coal 1 *B*. In Greenup and Carter counties it was examined:

At Chinch creek, Maysville Coal Oil Company, where four openings have been made into the cannel coal, which is 4 to 4½ feet thick, as reported on the section.

At Indian creek, where the bank is now concealed by debris, but seems to have the same characters as the former. The section is given by Mr. Lyon, vol. 3, p. 456.

On Col. Bradford's and Geo. Wurtz's land, two miles south of Fulton

furnace, where two entries have been made into the same cannel coal as the former. The coal is there 3½ feet thick.

In the bed of Whetstone creek, near Mr. John Steward's house, where it is 6 to 10 inches thick, half cannel, half bituminous, with abundance of fossil plants in the shales.

One and a half miles south of Raccoon furnace, where the cannel coal is 18 to 20 inches thick, and its shales are full of *Flabellaria* and *Lingula*. Here are two openings in the bank. On the land of Raccoon furnace the section is:

	Feet.	Inches.
Hard sandstone	6	
Bituminous coal		6
Black, bituminous, and micaceous shales, with plants and *Lingula*	3	
Cannel coal	1	6

Half a mile from this place, on the land of Buffalo furnace, it is:

	Feet.	Inches.
Gray micaceous shales	1	
Bituminous coal		2
Gray shales, with plants	2	
Cannel coal	1	
Bituminous coal		2

Near Raccoon furnace, 40 feet above No. 1 A, it has the same characters, and is 8 inches thick.

At Amanda furnace, on the hills facing the river, coal 1 B is represented only by the black bituminous shales bearing plants, especially *Flabellaria*. But back in the hills it is finely developed. 1st. At White Oak branch, 3 feet thick. It is here cannel coal, with a roof of soft shales, entirely covered with *Flabellaria*. 2d. At head waters of Pond run and Indian run, with the same characters. 3d. At Davidson's hollow, 4 miles west of the furnace, coal 4 feet thick, hard cannel, appearing entirely formed of *Flabellaria* and *Stigmaria*, visible in the coal; roofed with coarse micaceous gray shales. 4th. At Salisbury's hollow, 6 miles from Ashland, 2½ miles from railroad, coal 4½ feet thick. One foot of it is bituminous, separated by four inches clay parting from 3½ feet fine compact cannel. 5th. Below Mr. Wm. Morrow's house, on east fork of Little Sandy, where it is half bituminous, very shaly, about

5 feet thick, covered by black slates and overlaid by 12 feet of gray micaceous shales. The same vein crops out in the hills around in various stages of development.

Along the railroad from Ashland to Grayson, it is seen in near proximity with C. 1 C, (sections, p. 43, and Rep. 2, p. 355.) At Star furnace and Kilgore's, it is near the base of the hills connected with 1 C.

Around Buena Vista, on the land of Mr. Means, it is under gray micaceous shales, mostly in two members. The upper part, 8 to 14 inches, is coarse cannel coal or cannel shales; the lower part is bituminous coal, 1 foot thick. On Bush creek the cannel coal is fine, but only 6 inches thick. On Williams' creek, near Mr. Green's house, it has also fine cannel coal, ten inches thick.

At and around Greenup furnace, this coal takes a great development. It is opened at many places, and now worked for its cannel, rich in oil, and of excellent quality, (sect. p. 42.)

Near Hood's creek, on the land of the Bellfonte furnace, coal 1 B is worked 2½ feet thick, bituminous. It is roofed by brashy coal and gray shales, and placed 20 feet above earthy sandstone. It has above it three different coal stains, separated by fire clay and iron ore in a space of 21 feet.

On the land of the Pennsylvania furnace, this coal is apparently connected with No. 1 C. Its palæontology is obscure. At least, I did not find characters evident enough to place its different members with certainty. The section is:

	Feet.	Inches.
Yellow shales and sandstone, covered space	10	
Black bituminous soft shales		6
Bituminous coal	1	
Slate parting with few plants		6
Bituminous coal		6
Fire clay parting	1	
Bituminous coal	1	
Cannel coal		6
Fire clay	2	
Black shales	15	
Bituminous coal in bed of creek	1	

Near Catlettsburg, coal 1 B is opened on Horse branch, near the Ohio river, where its roof of gray shales is covered with beautiful specimens of its plants. Along Catlett's creek there are two other openings into

this vein. At the three openings the coal is bituminous. (Vide sections in Mr. Lyon's report, vol. 2, pp. 357–8.)

At Clinton furnace it is only a thin coal, half cannel.

At Grayson, Carter county, it has been worked in the hills for the salt works of Dr. Lansdown. It is there 3 feet 9 inches thick, with 3 to 4 inches clay parting. It appears to be covered with black bituminous cannel shales. The bank is now covered by a slide, and could not be fully examined. Along Little Sandy, above Grayson, this coal crops out at many places, and is said to be always cannel.

At Mt. Savage furnace coal 1 B is seen covered with gray shales, full of plants, near the bed of Pritchard's creek, half mile from the furnace. On the same hill, above this bank, the main coal is not formed. Behind the furnace, coal 1 B keeps its place by its shales and plants only, but it has no trace of coal; and the main coal makes its appearance 20 feet higher, separated from the shales of No. 1 B by a bank of sandstone. Both Pritchard's coal in creek and main coal must be referred to two divisions of No. 1 B. The main coal has at its bottom a brash coal, with abundance of plants. This is exactly, though in a larger scale, the same position as that of the veins of Stillwater, mentioned above, (page 40.)

Coal 1 *C.* As a separate vein, it has already been reported around Buena Vista and Greenup furnaces, generally 20 feet above 1 B. It is seen also, but unopened, on the land of Bellfonte furnace, and especially along the railroad from Ashland, at a variable distance from 1 B. It is worked 3 feet thick, just above the railroad, at Mr. Rouse's.

All along the Ohio river its place is occupied by a limestone, and the coal is not formed, or is thin. In the hills behind Ironton, in Ohio, it has black cannel shales and 10 inches coal.

I refer also to this vein a thin coal at Catlettsburg, 45 feet above 1 B, and the main coal of Clinton furnace, 30 feet above the cannel coal 1 B exposed in the creek. The black bituminous shales of Mt. Savage furnace, evidently belonging to C. 1 C, have already been mentioned.

Coal 2*d.* Is probably the vein badly opened at the head waters of Chinch creek, separated in two parts by 4 feet of shales, with plants. Each part of the coal is 15 inches to 2 feet.

On Whetstone creek, at Mr. John Steward's, it is opened 1 to 3 feet thick, at six different places, sometimes half cannel.

At Raccoon furnace its place is marked 100 feet above the creek by a streak of coal and a bank of shales.

This vein is worked as the main Amanda, the main Ironton, and the main Ashland coal, up in the hills, generally 4 feet thick, including a clay parting.

At Buena Vista furnace, it is opened above the church, 3 feet 8 inches thick, with a 3 inch hard shale parting.

At Catlettsburg its place is not marked, unless it be by a replacing limestone.

At Star furnace and Kilgore's, it varies in thickness from 3½ to 5 feet, including clay parting, and is 90 feet above coal 1 C.

At Stinson's hills, and at Mt. Savage furnace, it is marked by a stain of coal or a bed of shales, about 75 feet above coal 1 C.

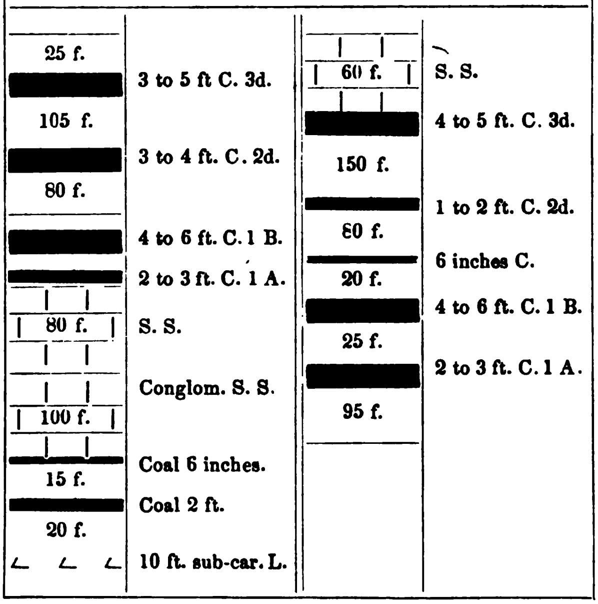
Coal 3d. Except at Stinson's hills and above Grayson, both places already reported, this vein is not worked any where in Greenup and Carter counties. The general remarks contain all that can be said about these banks. The beds of coal marked three feet and unopened, both at the top of the Amanda and Buena Vista sections, are referred to it, as well as the top coal banks of Raccoon furnace, and of Mr. J. Steward, at Whetstone creek.

Coal 4th. It has not been identified in Greenup and Carter counties, where the hills are generally too low to contain it. It may be also that it has not been formed in that part of the country, In Ohio, opposite Ashland, the Mahoning Sandstone tops the hills without any coal at its base.

MORGAN, BREATHITT, AND PART OF OWSLEY.

The disposition of the coal strata in these counties is not materially different. The section of Morgan county begins lower, and shows two beds of coal below the conglomerate. The section of Breathitt begins above the conglomerate, and its upper coal No. 3 is at a somewhat greater distance from No. 2. It shows already the increasing development of the coal measures to the southwest.

GENERAL SECTIONS OF MORGAN AND BREATHITT COUNTIES.—1 INCH FOR 200 FEET.



Morgan and Breathitt counties have certainly a great abundance of coal. Most of the creeks, in these counties, are strewn with pieces of coal, detached from unopened, mostly unknown, strata buried in the hills.

What was said of Muhlenburg, Ohio, and Daviess counties of the western basin, is also true for this part of the eastern coal fields. A few mines are worked near Jackson, for the trade of the Kentucky river, navigable for barges in the winter months; a few entries have been made also around West Liberty for an occasional transportation on the Licking river. But except this, there is at present very little trade in the coals of these counties. Their inexhaustible deposits of combustible mineral will, at some future time, become of great value, at least for home industry. The numerous outcrops reported below are only a specimen of this mineral wealth.

The coal strata below the conglomerate have already been reported. Our examination, therefore, begins with:

Coal 1 *A*. In Morgan county it has been seen—

At Old Latham coal bank, head waters of Glady creek.

On the road from Hazlegreen to West Liberty, in the bed of Grassy creek, with black shales above it, but still unopened.

On Little Caney, coal 8 to 12 inches thick, overlaid by 15 feet of black shales.

On waters of Caney, near Judge W. Lykins' house, coal 3 feet 2 inches under sandstone.

On the same creek, and two miles below the former, coal 2 feet thick under 8 feet of black shales.

One mile southeast of West Liberty, near the guide post, on the road to Louisa, coal 18 inches thick, with black shales above it.

In Breathitt county coal 1 A is, at Jackson, 18 inches thick, or more. The bank has been worked, but is now covered.

On Quicksand river, three outcrops of this vein have been reported with the sections. Another outcrop is seen on South's and Breck's claim; coal 14 inches thick, roof of black slates.

On Troublesome river, two outcrops of the same coal have been mentioned. There is still another, near the mouth of the river, in connection with No. 1 B.

On Cane creek, No. 1 A is only 4 to 6 inches thick.

On Puncheon Camp fork, it is 15 inches, and on Middle fork of Kentucky river, 1 foot, still covered with black shales.

In Owsley county, this coal crops out at Jett's and Meadow's creeks, as reported; coal 1 foot thick.

I could not ascertain if both the coal banks, the one at Booneville and the other on Back creek, three miles from the town, belong to this vein. At Booneville, the coal is said to be 20 inches, bituminous. It is covered with 3 feet of micaceous shales, without plants, overlaid by 8 feet of hard sandstone, with plants; very probably the sandstone of No. 1 A. Both coal banks were under water.

Coal 1 B, and its divisions, was seen in Morgan county, two miles south of Hazelgreen, where the gray shales only, with abundance of their characteristic plants and fruits, are exposed in the bed of a branch of Red river. Probably there is a coal under the shales. Among the plants examined, there was an abundance of *Sphenopteris artemisiæfolia*, Brgt., very rare in the American coal fields, though common in Europe, and a new *Odontopteris*, found also in Illinois, near St. Louis, on the same geological horizon.

On a branch of Stillwater, this coal has been reported before, as well as the opening on Blackwater creek.

On Nicholas' fork of Grassy creek, coal 6 inches.

On Little Caney it is of the same thickness, and separated from coal 1 C, 3 feet thick, by 30 feet of shales. This last coal is full of stems and poor. Many other outcrops of coal 1 B are seen along Little Caney; but they are generally thin.

On Elk creek, half a mile southeast of West Liberty, coal 1 B is connected with coal 1 A, about 18 inches thick, in two beds. On the same creek, at Mr. Robert Casca's, a vein of coal 1 foot thick, and another at Mr. Harrison Cole's, entirely cannel, and said to be 4 feet 8 inches, were covered, and could not be fully examined. They are referred to this vein with doubt.

At low water of the Licking, near West Liberty, the upper part of 1 B is 6 inches thick. It has above it the shales with the plants.

On Mordecai creek, at Mr. S. Schoolfield's, No. 1 B is finely developed, and mostly cannel coal, three to four and a half feet thick, at 6 different openings. No. 1 A is placed there 20 feet lower, as reported in the section of that coal.

At Mr. Wm. Davis', 3 miles southeast of West Liberty, on the waters of Caney, this vein has 2 feet of bituminous coal, and further up, at Mr. Allen Cassidy's, 15 inches.

On the land of Judge Lykens, waters of Caney, it is beautifully exposed at seven or eight different openings, mostly cannel coal. The distribution is generally thus:

	Feet.	Inches.
Micaceous shales or shaly sandstone of various thickness.		
Bituminous coal and black shales		10
Gray shales with the plants		6
Cannel coal	3	
Bituminous coal		8

At one of the openings, the coal is all bituminous, though in two parts, and only two feet thick; and at a short distance on the same level, the coal is cannel and 4 feet 3 inches thick. Down the creek it is seen near the road much divided, as follows:

	Feet.	Inches.
Gray metal and shales, with some plants	30	--------
Hard micaceous shaly sandstone, without fossils	--------	3
Bituminous coal	--------	2
Clay parting	--------	2
Bituminous coal	--------	4
Black soft shales, with plants	--------	2
Bituminous coal	--------	9
Soft fire clay, with stigmaria	--------	8
Bituminous coal	--------	6

Divisions like this are interesting for explaining the multiplication of the beds of this coal; whereas, in the east they become thicker, and form peculiar and separate strata.

On big branch of Lick fork, coal 1 B is 4 inches thick.

In Breathitt county, coal 1 B is seen:

On the waters of Frozen creek, near the road to Jackson, where the coal crops out all along the creek, half cannel, half bituminous. No. 2 is about 75 feet above it, and No. 3 is, perhaps, the bank formerly worked at Saml. Holmes', and said to be 3 feet thick. I found there some soft yellow shales, with plants. But the coal has been covered, and could not be seen. Another outcrop of coal in the same vicinity, at Mr. Day's, is also covered.

At Jackson, coal 1 B is worked 4 feet thick, at Mr. T. W. Cardwell's mines, and at Messrs. Jerry South & Sons. It is here a good bituminous coal, with a tendency to cannel.

On Quicksand creek, on Mr. Strong's land, where it is said to be 7 feet thick, and all cannel. The bank is covered.

At Meat Scaffold, branch of Quicksand creek, where it crops out about 8 feet above the level of the creek. This branch is full of pieces of cannel coal.

At Isaac Risner's, where it was reported to be 13 feet thick, I found it as follows:

	Feet.	Inches.
Covered space, apparently black shales	2	--------
Black fire clay and stigmaria	2	--------
Bituminous coal	1	6
Black bituminous cannel slates, with two thin streaks of poor coal	4	--------
Gray fire clay and shales	1	--------
Good bituminous coal	2	--------
Fire clay below.		

At Mr. Isaac Back's, 3 miles from Jackson, 6 inches, bituminous coal and 21 inches cannel; and near by at Mr. Roark's, where it has the same thickness.

The lower part of this vein, covered with the gray shales and plants, crops out 2 feet thick. One hundred yards above the mill of Quicksand, and just opposite the mill, its upper part, 2 feet thick, underlaid by the same shales and plants, is roofed by sandstone.

At Judge Alfred Combs', on Barge fork of Troublesome creek, where it is 2½ feet thick, half cannel.

On the Kentucky river, at Thos. Swells' bank, reported before.

On main left fork of Cane, coal 20 inches thick, with shales and plants at the bottom and sandstone above. Two of the outcrops on the same creek are reported.

Coal 2*d*. Is not much worked in the counties under examination. On head waters of Buck creek of Kentucky river, Morgan county, it is 3 feet 4 inches thick, with a 4 inch clay parting. It is there named Brown's coal. The coal is good, but whitish, with efflorescence of sulphates.

On branch of Lacey's, near Hazlegreen, where it is the Swango's coal, it has the same thickness, and same quality of coal, as the former.

At West Liberty, it is the Hazlerig's coal, 3 feet thick, separated into three members by two clay partings. It is there 75 feet from the upper member of No. 1 B exposed at low water of the river.

At Judge Lykins' it is not opened, but has been found in the hills between his upper and lower cannel coal banks.

In Breathitt county, its place is marked on Bone creek by 21 inches of bituminous coal.

About one hundred feet above the cannel coal of Mr. Roark, it is also marked by a streak, as well as below Haddocks' mine; but it is unopened at both places.

Coal No. 3d is better developed than the former; but its place in the hills is too high for convenience. At Jackson, 250 feet above No. 1 B, there is a streak of cannel coal marking its place, and it may be found to be a good coal in the hills around. It is extensively worked at Haddock's mines, and is probably Mr. Jno. Wells' coal bank, near the top of a high hill, between the Kentucky and Troublesome rivers. The coal is said to be 4 feet thick, and half cannel. It has been opened before, but

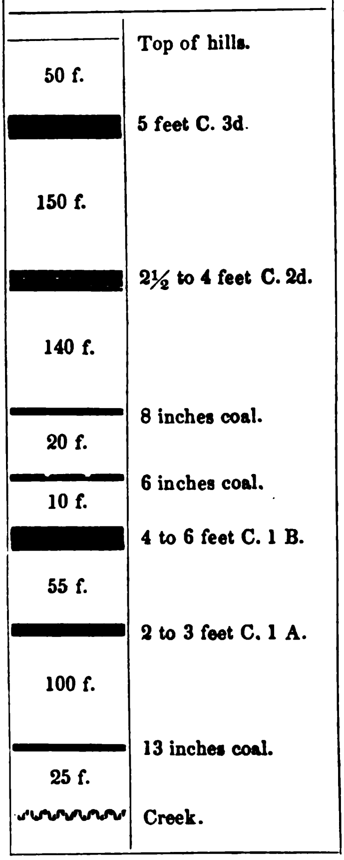
is now caved in. This coal will be found in thick strata, near the top of the highest hills of Quicksand and Troublesome river.

Its distribution in Morgan county is the same as in Breathitt. It has been opened near West Liberty, where it is the Cox's coal, and tops the highest hills of Caney creek, on the land of Judge Lyken.

LAWRENCE, JOHNSON, AND FLOYD COUNTIES.

In Lawrence, Johnson, and Floyd counties, No. 1 B is, as in Greenup county, generally at the water level;* but the measures increase in thickness, the coal strata are placed at a greater distance, separated by thick beds of sandstone; the country is deeper cut and the hills higher. The coal strata appear to follow the same rate of progression, and are generally more developed.

GENERAL SECTION OF LAWRENCE, JOHNSON, & FLOYD COUNTIES.—1 IN. FOR 100 FT.



The observation formerly made for Breathitt and Morgan counties, about the great amount of coal still unknown, remains true for these counties. The exportation is made only by the Louisa and Tug rivers; and as long as these rivers are not slacked, the navigation is too precarious to admit of active operations in the exportation of the coal.

A lower coal, 1 foot thick, is generally formed in these counties, just at the top of the conglomerate. It is exposed in Paints creek, near Paintsville, in Johnson county, and at some places along Blane river. In the boring of Warfield it is recorded 6 feet thick; but, like the coal below the conglomerate, the thickness is evidently overrated by counting with it the whole thickness of the black slates forming the roof of the coal.

Coal 1 A is apparently connected with 1 B in Lawrence county, at Gavit's and Peach Orchard mines. At Warfield, it is the main coal, worked 5½ feet thick, 70 feet below 1 B.

* Along the railroad from Grayson to Ashland, the geological horizon does not vary more than 20 to 30 feet in the whole length of the track.

In Johnson county, at and around Paintsville, it is generally 3 feet thick, covered with sandstone and overlaying a brash coal with plants. It is opened near Paintsville, at Messrs. Stafford & Hammond's. Its place is generally 40 to 50 feet below 1 B. In Floyd county it is of the same thickness and in the same position. Opposite Prestonburg it is 3½ feet thick and lies 35 feet below 1 B.

Coal 1 B was seen in Lawrence county, at Mr. Robert Eastham's, where it is 3 feet thick, bituminous coal and the top cannel. Near by, on Blane river, it is two feet thick, and is all cannel.

On Louisa river, at Calhoun mines, and at Peach Orchard, it is much divided, and thus its working is rendered troublesome and expensive.

On Tug river, opposite Louisa, it crops out under sandstone, and is there a thin coal, roofed by cannel shales, and is seen also two miles above, where it is in three members, with only 8 inches of good coal.

At Warfield it is apparently only 6 inches thick. But it is not certain that this streak is the only representative of the vein in the vicinity. A few miles down the river, the dip of No. 1 A being somewhat stronger than the slope of the river, it disappears, and No. 1 B makes its appearance near high water level, and is seen in a great bank of black shales, 25 to 30 feet thick, where it is divided into three veins of 6 inches to 1 foot each. Though coal 1 B is not opened at Warfield, its place is evidently marked by its position above 1 A, and by the presence of 1 C, 100 feet above it, and perfectly well characterized by its shales full of stems and the brashy nature of its coal.

This coal 1 B is exposed along the road from Warfield to Peach Orchard, especially on Rockcastle creek, always thin.

Near the road, about half way up the river from Peach Orchard to Paintsville, in Johnson county, it is opened under a bank of gray micaceous shales, with prints of *Lepidodendron*, *Flabellaria*, &c. The coal is half bituminous, and is two feet thick to the level of the creek; but its lower part is uncovered.

Seven miles below Paintsville, on Louisa river, it is 4 to 5 feet thick, mostly coarse cannel coal.

At and around Prestonburg it is the main coal, averaging 4 feet. Some of its outcrops are exposed along the river for 15 miles above Prestonburg.

At Paintsville, it is worked at Mr. Moses Preston's, on Muddy

branch, where it is of a bituminous character, with some cannel coal at the bottom, in all 4 feet 2 inches thick. Its roof is a gray shale, marked with numerous impressions of plants. It has been opened also at a short distance just above Louisa river, 1½ mile below Paintsville, 160 feet above low water, where it is bituminous coal, thirty inches thick.

On the land of Dr. H. F. Strong, 1 mile west of Paintsville, No. 1 A and 1 B are seen at their respective places, but not opened.

As reported before, Mr. Jesse Wheeler works this coal 4 feet thick in the same vicinity.

Coal No. 1 *C.* The coal banks referable to this vein have been all mentioned.

Coal No. 2. Reported at Gavit's and Calhoun's mines, on Louisa river, 3 to 4 feet thick, mixed with clay partings. At Peach Orchard, where it is the main and only workable bed. At Paintsville it has been opened, but never worked, and at Prestonburg it is perhaps a coal said to be 2 to 3 feet thick, 130 feet above main. I could not see it. At Warfield it is 4 feet thick, and is sometimes half cannel.

Coal 3*d.* On account of its high position in these counties it has not been examined to any extent. It is opened near the top of the hills, above the falls of Blane river, Lawrence county, where it is all cannel. At Warfield it is said to be 7 feet, and at Paintsville 5 feet, where it is also cannel. The openings in these three last coal banks are very partial, and so that I could see only the top shales. At Calhoun mines, on Louisa river, it is 100 feet above No. 2, and said to be 6 feet thick. The top layers exposed are a true cannel coal.

COMPARATIVE SECTIONS.

This report is concluded by a sectional table, showing the comparative position of the most important coal strata in different parts of the American coal fields. The number of the sections could have been much increased; but I have deemed it best to record only in this table those which I consider as perfectly reliable, and of which I have been able to compare the palæontological characters, at least at some of their principal horizons.*

The remarkable analogy of distribution of the coal strata, as indicated

* All the coal beds, the position of which has been ascertained by such palæontological evidence, are marked by a (*).

by those sections, is thus put in evidence, and cannot be ascribed to any ideal system. The order of superposition of the different sections is established on lithological and palæontological characters. But it is only by palæontology that the equivalency of the coal strata has been, and can be, established in distant parts of the same basin, and especially in separate coal fields. Therefore palæontology, as applied to the identification of coal beds, can no longer be considered as a chimerical notion. Its practical advantage is at once evident. And I have no doubt that, as soon as it is generally received as a guide in the examination of our coal fields, the harmony of distribution of the coal strata will become more and more striking.

The sections made in Kentucky indicate a remarkable increase in the thickness of the measures, especially of the sandstone strata towards the southeast. It would have been interesting to compare sections made in the coal fields of Virginia, south of Charlestown, and to ascertain how far this progression of thickness is continued. It was impossible to get reliable data on the distribution of the coal in that country. From what I have seen myself, many years ago, and especially from sections on Coal river, kindly communicated by Dr. I. H. Salisbury, it appears that coal No. 1, with its members B and C, and perhaps No. 2, multiply and form as many as eight different strata. A similar development is seen in the north anthracite basin, of which Wilkesbarre is the center. And in the same basin we find another analogy in the constant decreasing of the measures from Wilkesbarre to the eastern edges of the basin at Carbondale.

It was also impossible to get any well ascertained data from the other basins of the Anthracite coal fields. The disturbances of the strata are so marked in innumerable flexures that dynamical geology has failed, till now, to give any indication about the general distribution of the veins. From palæontological evidence I am satisfied that the highest coal of the Pottsville and Tamaqua basin is the equivalent of our No. 4th, and that the measures do not ascend higher in that part of Pennsylvania. It is certain also that the *big* or *mammoth vein*, so generally worked in the same basin, is the equivalent of No. 1 B.

The 1st section represents the distribution of the coal strata in Union county, Kentucky, and is perfectly correct. It was made by Dr. D. Dale Owen, from borings and repeated measurements.

Section 2 is the record of the Holloway boring at Henderson, and is also perfectly reliable for the place of the coal strata in this part of Kentucky.

Section 3d belongs to Mr. J. P. Lesley's Manual of Coal. It was condensed from such numerous and authentic records as the best geologist can obtain.

Section 4th is another general section of Pennsylvania copied from the State geological final report of Pennsylvania. In comparing these four general sections, it becomes evident that the essential coal strata, viz: coal 1 B, C 4th, and C 11th, come just under the same horizon. The difference in the intermediate strata is not of material importance. In the section of the Pennsylvania survey there is a distance of 480 feet marked as barren of coal, contradictory to local sections of the same Report, which show generally one workable bed, the *Elklick coal*, and sometimes two, above the Mahoning Sandstone. Mr. Lesley's section has marked the place of these strata. In the same section of the report, there is a group of veins, called the Mercer coal, which has no equivalent in the other sections, or which is represented only by a thin coal. Palæontology only could decide if this Mercer coal is not the equivalent of No. 1 B and its subdivisions, as it appears to be.

From all the local sections of the Pennsylvania Survey, two ascertained data are especially worth mentioning. 1st. The reliability of our Curlew limestone, which, in Pennsylvania, is called Freeport limestone, and is generally placed 6 to 15 feet above our No. 3d coal. 2d. The consistency of the *ferriferous* limestone between No. 1 B and No. 2 in the place occupied by our coal 1 C. It lies, as in Kentucky, 10 to 40 feet above No. 1 B, and is generally accompanied by calcareous iron ores.

Section 5th, at Yellow creek, is given from measurements of Dr. Newberry, in his railroad survey, and from my own palæontological examination. The distances between the coal strata are said to be too great.

Section 6th was made at Buena Vista and Greenup furnaces from my own measurements, compared with five different sections, kindly furnished by Mr. John Means.

Section 7th, made at Mount Savage, is exact, as far as measurements by pocket level can be relied upon.

Section 8th was taken at West Liberty, first by Dr. D. D. Owen, and afterwards by myself. The upper part of No. 1 B crops out in the bed of the river, and it was impossible to ascertain at what distance this member, one foot thick, is placed from the main 1 B. The distance, 71 feet, to No. 2, is too short by, probably, 20 to 30 feet.

Section 9th, at Jackson, only shows No. 3d coal as a streak of coal 6 inches thick. The section was followed along a steep ravine, from the bed of the river to the top of the highest hill. Though this coal was covered, and its palæontology was not ascertained, I have no doubt of its identity with the Haddock's coal, our No. 3d, which is worked in the vicinity, 275 feet above No. 1 A.

Section 10th, at Peach Orchard, was ascertained from measurements and palæontological data. Coal 3d is only marked by a hard bed of fire clay, nearly limestone, or bastard limestone, and a streak of coal, and coal 4th is replaced by fire clay and iron ore, just at the base of the Mahoning Sandstone, which tops the hills, 520 feet above low water of Louisa river, and is conglomeratic at its top.

Section 11th, at Warfield, is made from No. 1 A coal, at the top of the boring to the highest hill, 740 feet, where all the coal strata are opened, nearly on the same vertical line. I refer the cannel coal vein, said to be 8 feet thick, to No. 3, and not to No. 4, because it is not placed just below the Mahoning Sandstone, but separated from it by about 90 feet of measures, apparently shales and iron stone. I could find no trace of coal 4th; but the top of the hill, except where the Mahoning Sandstone appears in perpendicular cliffs, is covered with a nearly impenetrable thicket of brambles, which rendered close researches impossible.

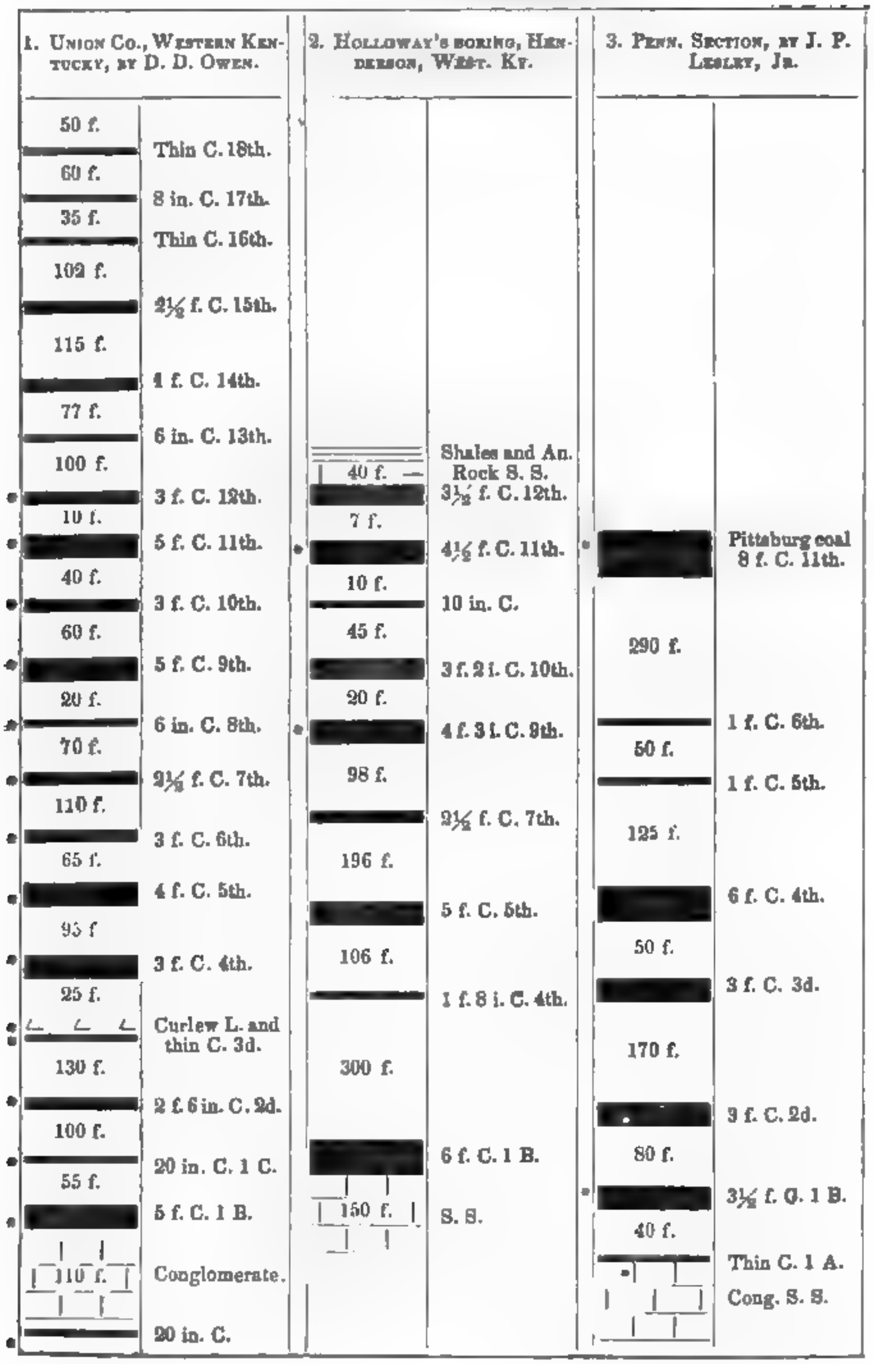
Section 12th was taken at Wilkesbarre, in the center of the north anthracite basin. This and the following sections were copied from the report of the Pennsylvania survey, and were especially compiled from borings and observations made by the directors of coal mines. They are certainly reliable. For Wilkesbarre, there is an upper section containing two beds of coal, which would correspond with No. 5th and 6th coals of Kentucky. As this section was not taken from the same place as the lower part, and as I could not see any of the reported coal beds so as to ascertain their palæontology, it is omitted. Some coal beds of unworkable thickness are marked in the section of the Pennsylvania report. But they are not reported by Mr. Lesley, nor were they marked in a section which I obtained of the foreman of the mines.

Section 13th, at Pittston, is remarkable by the separation of coal 2d and C. 3d, each into two beds, separated by 10 feet of shales. We have seen the same disjunction of these veins at Chinch creek, and at Whetstone creek, in Greenup county.

Section 14th, at Scranton, is also reported in Mr. Lesley's Manual, with some difference.

Section 15th, at Carbondale, was obtained from Mr. Ed. Johnes, director of the mines of Archibald. At Carbondale the hills are too low, and contain only the coal 2d. The 3d coal is added from the Archibald's section, which is about the same. In this last place, the distance between C. 1 B and 2d is 92, and at Carbondale 95 feet.

TABLE OF SECTIONS.



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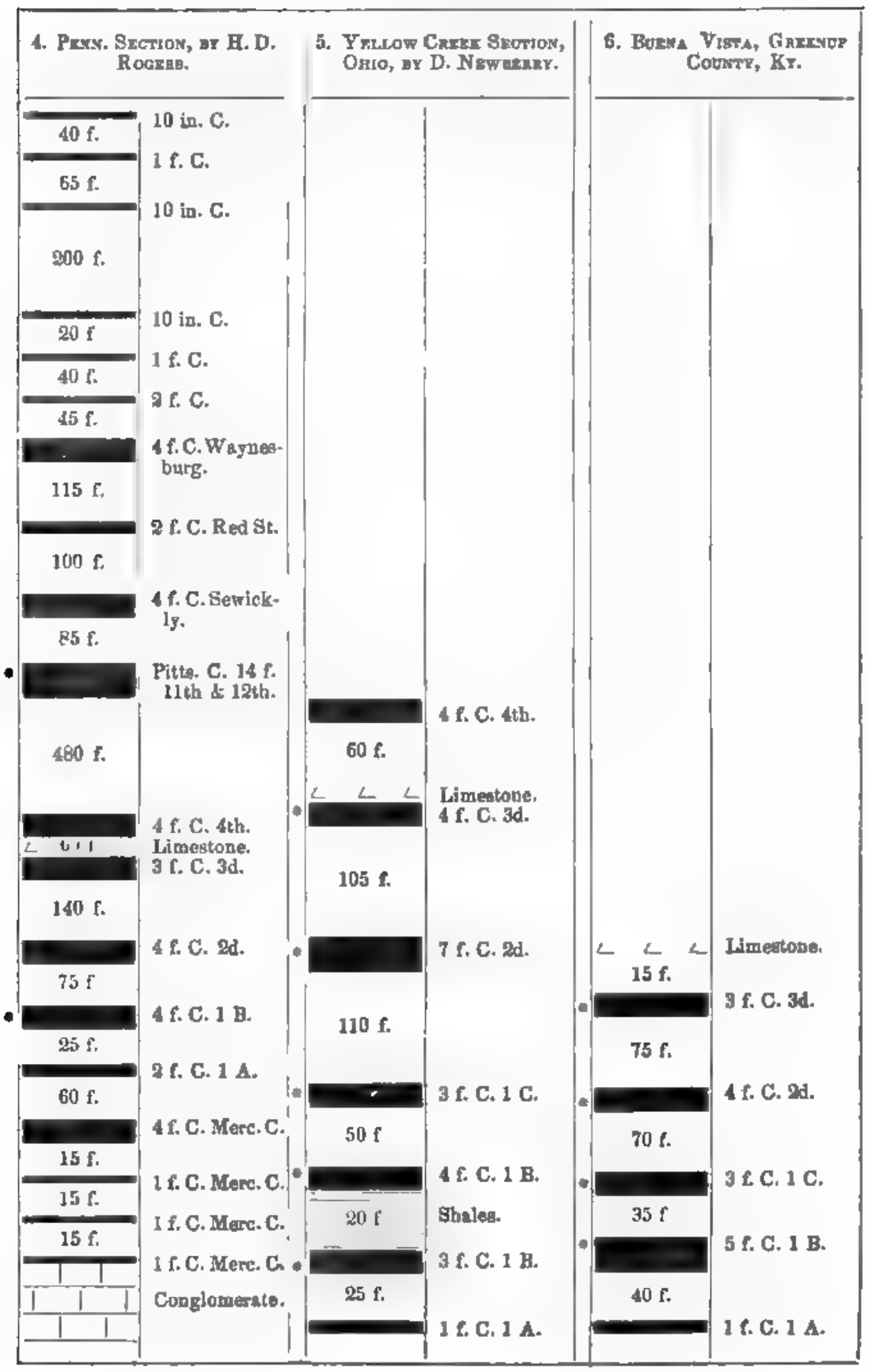

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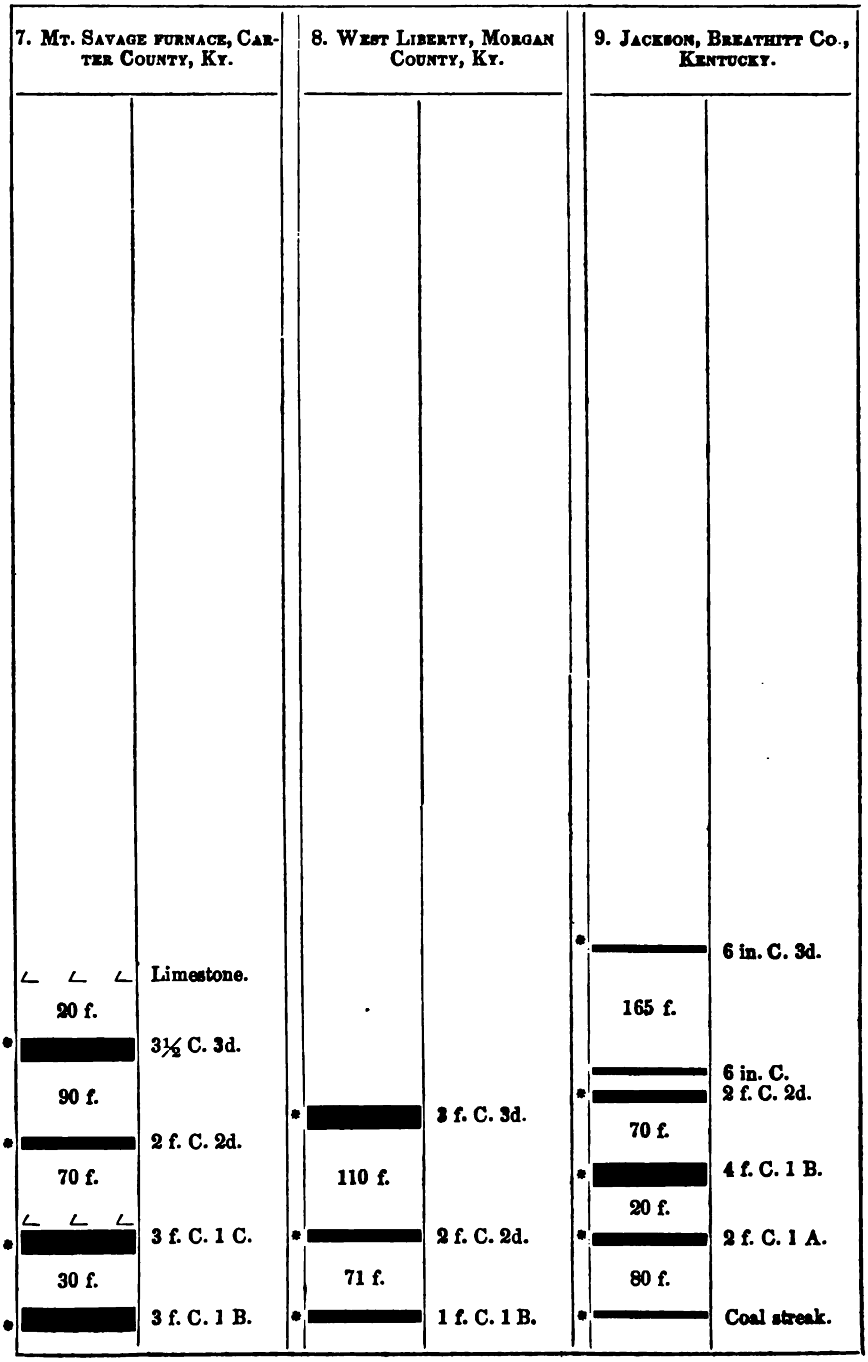

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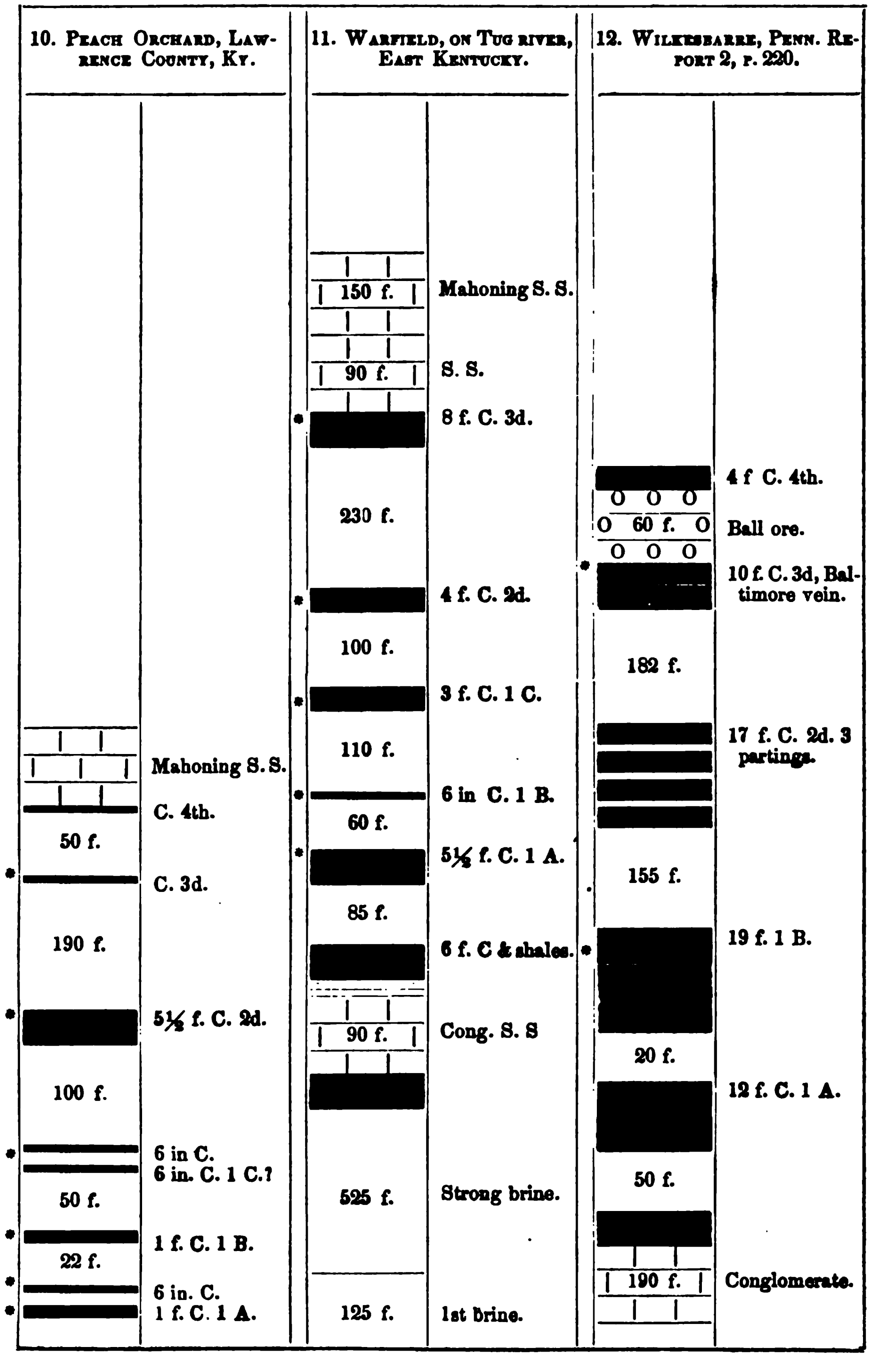

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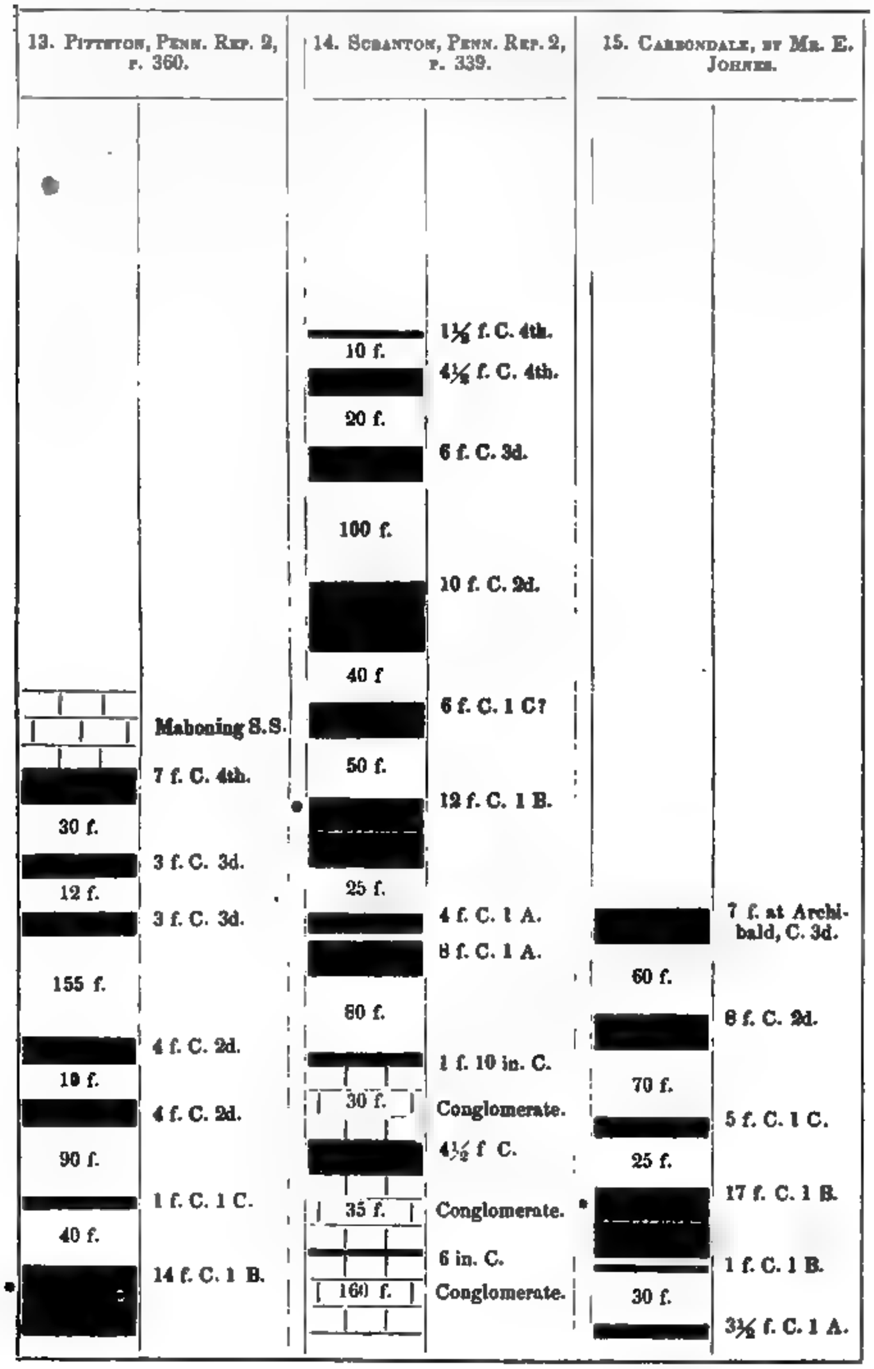

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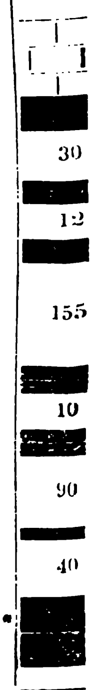


EXPLANATION OF THE PLATES

AND

DESCRIPTION OF THE SPECIES.

PLATE I.

Fig. 1 and 1 a. *Dictyopteris obliqua*, Bunby. Species easily known by the peculiar reticulation of its nervules or veinlets. Fig. 1 a is somewhat enlarged, and more distinctly elucidates the nervation. This species is sometimes found in coal No. 1 B, but mostly in No. 3d.

Fig. 2 and 2 a. *Alethropteris Coxiana*, Lsqx. This fine species, found by Prof. E. T. Cox and myself, at the Union mines, Livingston county, has the leaflets obliquely decurring on the rachis, united near the base, oval-lanceolate in outline, and irregularly sinuate. The medial nerve is thin, or scarcely marked; secondary nerves thin, obliquely arched, generally twice forked. Fig. 2 a, enlarged size. This species is related to *Alethopteris sinuata*, Brgt., but is evidently distinct: by its *more oblique* nervules, sometimes *nearly perpendicular* on the medial nerve; by the form of the *distant* leaflets, which *are more pointed, united above the base*, and by *a plane* (not undulate) surface. The figured specimen is the best which was found, though the species is abundant on the shales of Union mines.

Fig. 3 and 3 a. *Alethopteris Serlii*, Brgt. Easily distinguished from its relative, *Alethopteris lonchitica*, Brgt., by its shorter, broader leaflets; by the broad, flattened medial nerve of the leaflets; by the more divided and thinner veinlets, and by its narrow rachis. It is especially found in the shales of coal No. 3d, while *Alethopteris lonchitica* is a characteristic plant of coal No. 1 B.

PLATE II.

Fig. 1 and 1 a. *Pecopteris arborescens*, Brgt. Rachis thick, often dotted with irregular points, which show the base of obliterated scales. Leaflets half round, irregular in size, united near the base; nervules simple, as marked in fig. 1 a, which is enlarged. This species is very

Fig. 2 and 2 a. *Pecopteris unita*, Brgt. It takes its name from the position of the leaflets, generally united nearly to the top. The distant, thin, and peculiar nervation of this species is marked in fig. 2 a, enlarged. It has been found till now only in connection with coal No. 3d.

Fig. 3 and 3 a. *Pecopteris arguta*, Sternb. Frond bi or perhaps tripinnate. Pinnæ long, about half a foot, perpendicular to the rachis; pinnules alternate, long, narrow, lanceolate oval, obtusely pointed, united nearly from the middle. Nervules thick, flat, oblique to the thick medial nerve, straight, running to the margin. The cellular tissue of the leaflets of this species being soft and easily decomposed, the natural outline, either entirely or partially destroyed, is sometimes changed, and the leaflets appear thus, either serrulate by the protruding veinlets, or as a bundle of threadlike parallel nervules, which have been described as a peculiar species. It is found in the shales of No. 4th coal.

Fig. 4. *Rhabdocarpos arcuatus*, Lsqx. This peculiar fruit is, in its outline, somewhat like a pea-nut. It appears to have been covered with a woody envelop or shell about as thick as a common nut-shell. This outer envelop is now transformed into coal, and narrowly striated. Under it, the fruit is parallelly ribbed, dotted on the surface with small holes. It is borne on a pedicel about one half inch long. I found three specimens of this beautiful species on Burnt branch of Caney, near West Liberty, Morgan county, in the shales of coal No. 1 B.

Fig. 5 and 5 a. *Hymenophyllites Hildreti*, Lsqx. The frond of this species appears much divided, alternately forking. The leaflets are either simple, linear-oval, or enlarged and bi or tri-lobed. Each division is marked by a single nerve descending to the branch of the stem, which is somewhat inflated in the middle, or marked by a strong nerve. This species is commonly found in the shales of coal No. 1 B and No. 3d.

Fig. 6 and 6 a. *Hymenophyllites artemisiæfolia*, Brgt. The frond is apparently bi-pinnately divided. The leaflets are wedge-shaped, roundish, or eroded at the top, obliquely decurring on the rachis, joined together near the base, and marked with thin parallel veinlets. This species appears to be rare in the American coal fields, though common in Europe. I found it in a bed of the shales of coal No. 1 B in a branch of Red river, two miles south of Hazlegreen, Morgan county.

Fig. 7. *Neuropteris vermicularis*, Lsqx. This species, by the form of its leaflets, is exactly like *Neuropteris flexuosa*, Brgt., only the base

of the leaflets is round, and not expanded on one side. The nervation is very different. The veinlets are thinner, more deeply or strongly marked, and more distant. They are generally so sharply exposed that they can be detached from the leaflets like bits of hair, or like small pieces of rain worms. This species was found at many places, only in the shales of coal No. 1 B. Generally the leaflets are detached from the stem.

PLATE III.

Fig. 1. *Cordaites borassifolia*, Ung. By its broad, long leaves, narrowed at the base and embracing the stem, generally cut, sometimes rounded at the top, with the surface narrowly striated, this species is related to the family of the palm trees. It is very common in the shales of most of the coal strata, from the sub-conglomeratic coal of Arkansas to No. 1 B, No. 3d, No. 4th, and even No. 8th, of the coal strata of Kentucky.

Fig. 2 and 2 a. Leaves of *Lepidodendron*, with an enlarged cross section at fig. 2 a. These leaves, most common with the shales of the sub-conglomeratic coal, have been sometimes described as blades of grass, or as leaves of *Sigillaria*, or with some peculiar names. They are variable in length, but the form is generally the same. When they are found entirely flattened in the shales, they appear as marked by two parallel nerves in the middle.

Fig. 3. *Asterophyllites tuberculata*, Brgt. I have figured, as well as possible, this kind of ear, composed of parallel rows of appressed, apparently oval-obtuse scales. These ears are very abundant in the shales of coal No. 3d, but always broken, and never attached to any stem. They do not appear to contain, within or under the scales, any seeds or granules Though they are generally found mixed with stems and leaves of *Asterophyllites*, they cannot belong to this genus, unless *Asterophyllites* are considered as branches of *Calamites*, and *Asterophyllites tuberculata* as a kind of male flower or cone, bearing pollen, attached immediately to the trunk of *Calamites*, where it leaves, in falling from it, those large, round scars, observed on some species of *Calamites*. The true fruit, or cones, of *Asterophyllites* are much smaller, or appear to be tubercles or nutlets attached around the stem in the axil of the leaves.

Fig. 4. *Calamites decoratus*, Brgt. This fine species has been considered by some authors as a variety of *Calamites approximatus*, Brgt.

But it appears truly different—by its well marked, very thinly striated ribs; by its double range of tubercles around the transversal line of separation, and by a thin, but well marked, line at each side of the ribs. It is commonly found in the shales of coal No. 3d, and has not been seen elsewhere till now, while *Calamites approximatus* abounds with coal No. 1 B.

Fig. 5. *Calamites gracilis*, Lsqx. This species, without any trace of leaves, has just the appearance of a horse-tail or *Equisetum*, and thus may belong to the genus *Equisetites*. But the sheaths are not well marked and replaced by a thin coat of coaly matter; the true genus of the plant cannot, therefore, be ascertained. It appears to have lived in water, being found in the coal shales of No. 8th coal, in connection with marine shells and a black band limestone.

PLATE IV.

Fig. 1 and 1 a. *Asterophyllites equisetiformis*, Brgt. It has the leaves in rows of 8 to 14 leaflets, which are linear acute, from half an inch to one inch long, marked in the middle by a broad nerve. Fig. 1 a is enlarged. The rachis is generally somewhat and irregularly striated. Though this species is considered by some authors as belonging to a *Calamites*, it has never been found attached to the stem of a true *Calamites*. It is common from No. 1 B to No. 4th coal beds, most generally with coal No. 3d.

Fig. 2 and 2 a. *Sphenophyllum Schlotheimii*, Brgt. Leaves in a row of six cuneate, enlarged leaflets, which are truncate and crenulate at the top. Veinlets forking twice, nearly parallel, and running to each of the notches of the crenules. The number of the veinlets is thus just the same as that of the notches, viz: about ten. This species, like the following, lived on the surface of the water, where its leaflets were expanded. It has the same stratigraphical distribution as the former. Fig. 2 a is a leaflet enlarged to show the nervation.

Fig. 3. *Annularia fertilis*, Sternb. Leaves in rows of 16 to 20, oblanceolate, narrow, notched leaflets, apparently recurved along the margins, and perhaps fruit-bearing under their surface like the ferns. All the European specimens figured of this species have pointed leaflets. But I do not think that this difference has a specific value. Another species of this genus, *Annularia sphenophylloides*, Ung.; very common in the shales of coal No. 3d and 4th; has both pointed and notched

leaflets, sometimes on the same specimen. It differs only from the one figured here, by its much smaller size and fewer leaflets. Same range of distribution as both the former species.

Fig. 4 and 4 a. *Lycopodites cavifolius*, Lsqx. Stem apparently slender, forking; leaflets imbricated, lanceolate-oval, acute, half embracing the stem at the base, concave, with an obsolete nerve in the middle. The form of the leaflet enlarged and figured at 4 a, is taken from very concave impressions on the stone. It cannot be compared with any of the Lycopodites published till now. Found in the shales of coal No. 1 B.

Fig. 5. *Sigillaria corrugata*, Lsqx. A species somewhat related to Sigillaria dilatata, Lsqx., (Penn. Rep., p. 871, pl. 13,) but separated from it by its transversally wrinkled surface and its broader scars. Shales of No. 1 B coal.

TOPOGRAPHICAL

AND

GEOLOGICAL REPORT

OF THE

COUNTRY ALONG THE OUTCROP BASE LINE, FOLLOWING THE WESTERN MARGIN OF THE

EASTERN COAL FIELD

OF

THE STATE OF KENTUCKY,

THROUGH THE COUNTIES OF

CARTER, ROWAN, MORGAN, BATH, MONTGOMERY, POWELL, ESTILL, OWSLEY, JACKSON, ROCKCASTLE, PULASKI, WAYNE, AND CLINTON, FROM A SURVEY MADE DURING THE YEARS 1858-9,

BY

JOSEPH LESLEY, Jr., Topographical Assistant.

INTRODUCTORY LETTER.

PHILADELPHIA, November 1, 1859.

To David Dale Owen, State Geologist:

SIR: In compliance with your instructions, I herewith submit my Report of the Geological and Topographical Survey, for determining the western outcrop of the eastern coal field of Kentucky, made during portions of the years 1858 and 1859.

Very respectfully, yours,

JOSEPH LESLEY, JR.,

Assistant in Geological Survey of Kentucky.

REPORT.

INTRODUCTORY REMARKS.

According to instructions received at the time of my appointment as Assistant of the Geological Survey of Kentucky, on the 5th of April, 1858, I made the necessary preparations to "prosecute and extend the Geologico-Topographical Survey along the margin of the eastern coal field;" and for that purpose started for headquarters, at Lexington, on the 25th of August following, where I was joined by my Assistant, Mr. William Whitehead, and his rodman, and thence proceeded to Irvine, in Estill county, that being selected as the most fitting point from which to commence the *outcrop base line* of the eastern coal field.

Work was commenced upon the 1st of September, and was actively prosecuted until the 13th of December, when the party returned to Lexington, and was disbanded. During the winter Mr. Whitehead was employed in working up the field notes in the office, and in obtaining data, such as copies of surveys made by the State and by the Lexington and Big Sandy railroad, the latter to be incorporated in our own work.

The corps again met at headquarters, in Lexington, on the 11th of April, 1859, and, proceeding to Irvine, as before, started from a point near that town, and pushed the line southwestwardly until it reached the southern border of the State, when the party returned to Lexington, and was disbanded on the 3d of September last, since which time the office work has been constantly in hand.

In running the outcrop base line, roads being selected, an odometer was used for the measurements, and a compass with side telescope and eccentric target for the courses. The compass was furnished with a clinometer for taking the angle of the slopes, enabling the compassman to check the barometric observations which were regularly taken at every station by the target-man; but as one of the objects of this survey was to "serve as the groundwork for the construction of a correct geographical map of the State," it was deemed necessary to follow with the spirit level, in order not only to fix positive starting points for the barometric

observations, but also to establish the exact height above tide of the principal stations along the line. These levels were of additional value for determining the dip of the rocks; while the bench marks, which may be found at nearly every fork of the road, will remain as sure starting points for future State or county surveys. As experience has shown that the original notes of surveyed lines, either for railways, turnpikes, canals, rivers, or common roads, are rarely to be found when wanted, I herewith add a table showing the number, description, and locality of each *bench mark*, with its elevation above low water of the Ohio river, at Catlettsburg, the datum level of the Lexington and Big Sandy railroad, and also above tide, as obtained from the published report of Mr. Ellet on the Mississippi and Ohio rivers:

DESCRIPTIVE TABLE OF BENCH MARKS.

No. of bench mark.	CARTER COUNTY.	LEVELS. Above Catlettsburg.	Above tide.
1	On a sycamore, ¼ mile east from Grayson, and on the left bank of the Little Sandy river	101.079	597.079
2	On the S. E. corner-stone (below string-course) of the court-house in Grayson	200.830	696.830
3	On a beech, ¼ mile east from the Mt. Savage furnace, and 200 feet from the junction of Gum branch with Straight creek	127.054	623.054
	On a beech, 250 feet above R. McGuire's house, and on the north side of the Grayson and Mt. Savage furnace road	126.071	622.071
	On a white oak, in Wolf creek valley, near crossing of Grayson and W. Liberty road	177.080	673.080
4	On a white oak, on the Grayson and West Liberty road, near the mouth of a run above J Savage's house	170.955	666.955
5	On a beech, on the right bank of the Little Sandy, opposite the house of Greenup Clay, and near the Greenbriar creek road	136.275	632.275
6	On an ash, on the left bank of Bruin creek, and at forks of road to W. Liberty	137.382	633.382
7	On a cherry, below Abijah Whitt's house, and at a fork of the road leading to Tygert's creek	201.950	697.950
8	On a beech sapling, (against a poplar,) near H. M. Skegg's house, at a fork of the road leading westwardly to Olive Hill P. O.	336.516	832.516
9	On a beech, at a fork of the road leading to Tygert's creek bridge	345.180	841.180
10	On a white oak, on the dividing ridge between Little and Big Caney creeks, and at a fork of the road leading to Triplett's creek	448.603	944.603
	Bed of Little Sandy river, at the mouths of Laurel and Open forks	150.926	646.926
11	On a sugar tree, 1,380 feet above Cook's store, on the right bank of Open fork	220.617	716.617
12	On a sugar tree, at a fork of the road leading to West Liberty via Enoch's creek	243.199	739.199
13	On a mulberry, 630 feet above the last mentioned forks in road	256.017	752.017
	Water shed, between Open fork of Little Sandy and the North fork of Licking river	[illegible].373	10[illegible].373

DESCRIPTIVE TABLE—Continued.

No. of bench mark.	MORGAN COUNTY.	LEVELS. Above Cattlettsburg.	Above tide.
14	On a black oak, near Cox's house and on road leading from Hampton's mill to West Liberty	300.394	796.394
15	On a large chestnut, on the west bank of the Licking river, and near Hampton's mill	266.800	762.800
	Foundation of Hampton's mill	237.453	733.453
16	On a chestnut oak, in the forks of the roads leading to Hampton's mill and to Hazlegreen	721.330	1217.330
17	On a white oak, in the valley of Brushy fork of Beaver creek, and in forks of road to Owingsville	630.639	1126.639
18	On a white oak, near where the Brushy fork road comes into the State road	771.478	1267.478
19	On a small white oak, on "Dry ridge," at the head of McCormick's branch of Beaver creek	789.032	1285.032
	BATH COUNTY.		
	Summit, on State road between Slate and Beaver creeks	765.200	1261.200
	MONTGOMERY COUNTY.		
20	On a large white oak in Slate creek valley, on the right of the State road, and 50 feet west of road leading to Red river	364.594	860.594
21	On a large double black oak, in a grove near the village of Jeffersonville	362.669	858.669
22	On a black oak, on one of the branches of Lulbegrud creek, and at fork of road to Stanton	350.964	846.964
	ESTILL COUNTY.		
	Low water of Red river, at mouth of Black creek, near the Powell county line crossing	123.300	619.300
	Top of the lowest course of stones at the N. E. corner of the Estill furnace stack	765.204	1261.204
	Top of the "State House" rock, near Estill furnace	968.250	1464.250
23	On a black oak, on a dividing ridge between Miller and Cow creeks, to the east of the Cow creek road, (the tree is marked, "221 miles + 2,004 feet")	892.369	1388.369
	Top of the S. W. foundation corner of cells in the new jail in Irvine	203.766	699.766
	OWSLEY COUNTY.		
62	On a black oak, at a point where the road from Proctor intersects that from Estill furnace to Hazlegreen	763.324	1259.324
	Top of the "Standing Rock," at the corners of Powell, Estill, and Owsley counties	772.784	1268.784
60	On the S. W. corner of the foundation of the steam mill stack, in Proctor, at the mouth of the South fork of the Kentucky river	174.838	670.838
	Low water of Kentucky river, at the mouth of Sturgeon creek	130.359	626.359
59	On a white oak, to the right of road in Duck creek valley, 700 feet above Sturgeon creek road forks	162.253	658.253
58	On a chestnut oak, at a point where the path from Sturgeon creek comes into the Booneville and Irvine road, and on the dividing ridge separating Station Camp creek waters from those of Grassy and Granny-Dismal branches	794.192	1290.192
	JACKSON COUNTY.		
56	On a poplar, in the valley of Wild Dog creek, 50 feet north of the Manchester and McKee road	507.190	1003.190

DESCRIPTIVE TABLE—Continued.

No. of bench mark.	JACKSON COUNTY—Continued.	LEVELS. Above Cat-lettsburg.	LEVELS. Above tide.
55	On a hickory, at the forks of the Big Hill and Manchester road, on dividing ridge between War fork and Laurel fork	867.103	1363.103
54	On a white oak, in Indian creek valley, 1,600 feet east of the jail in McKee	544.352	1040.352
	ROCKCASTLE COUNTY.		
51	On a large white oak, to the right of the county road, 50 feet from the Madison turnpike, and near Mr. Golding's, on the Big Hill	1058.590	1554.590
50	On a chestnut oak, on the left bank of Roundstone creek, near road crossing below house of Pleasant Fish	417.556	913.556
49	On the N. W. corner of the foundation wall of the Mount Vernon court-house	660.764	1156,764
48	On a black walnut, to the east of the Crab Orchard turnpike, and 125 feet east of Wm. Jones' house, and near forks of road to Skeggs' creek	880.640	1376.640
46	On a sugar tree, marked "6,871," standing on the north side of Skeggs' creek, 1,100 feet above Holbert McClure's house	366.587	862.587
	PULASKI COUNTY.		
45	On a sycamore, in the bed of Line creek, at the junction of the London, Crab Orchard, and Somerset roads	397.612	893.612
44	On a black walnut, in Dobbit's grave-yard, near Dallas P. O.	473.580	969.580
43	On a post oak, on ridge at forks of road to Buck creek, Crab Orchard, and the coal banks	718.159	1214.159
	Low water in Buck creek, at road crossing below W. R. Mize's house	258.900	754.900
42	On a white oak, to the west of Buck creek, southeast of the Bend meeting-house	554.417	1050.417
40	On a black walnut, near the house of John Bratcher Lee, on the Pittman's creek road, on right bank of the creek, and 306 feet from road crossing	340.631	836.631
39	On a black oak, near the mouth of Sinking creek, and near the house of Woods Leece	334.250	830.250
	Low water of the Cumberland river, at Waitsboro'	77.700	573.700
37	On a large elm, on the left bank of the Cumberland river, near the ford below Waitsboro'	107.199	603.199
36	On a black oak, near Long's mill, on the South fork, and at fork of road leading to the Jacksboro' road	396.777	892.777
	WAYNE COUNTY.		
35	On a sugar tree, at the cross-roads, at the Three forks of Big Sinking creek	364.179	860.179
	Summit, (at road crossing,) dividing Elk Spring from Big Sinking creek waters	802.500	1298.500
33	On a red oak, near the Widow Goddard's house, in the Elk Spring valley	477.059	973.059
	Top of the N. E. corner of the N. door sill of the Masonic hall, in the town of Monticello	439.019	935.019
30	On a white oak, ½ mile west of Newberry P. O., at the forks of the Livingston or old Alabama stock road	474.885	970.885
	CLINTON COUNTY.		
29	On a large black oak, near the Widow Owen's house, and at forks of road leading to Rowena	572.321	1068.321

DESCRIPTIVE TABLE—Continued.

No. of bench mark.	CLINTON COUNTY—Continued.	LEVELS.	
		Above Catlettsburg.	Above tide.
	Summit at Wade's gap	813.800	1309.800
28	On a black oak, between Spring creek and I. Sloan's house, one mile north of Elliott's cross-roads	385.653	881.653
27	On a white oak, east of the Livingston or Alabama stock road, and 80 feet north of the Tennessee State line	523.184	1019.184

The smaller of the two maps accompanying this Report is intended to show at a glance the whole extent of the great eastern coal and iron field of Kentucky. It was compiled from the notes of the Survey, from old maps in the Internal Improvement office, and from railroad surveys, upon the basis of the large published map of the State, and correcting some of its numerous errors. New counties have been inserted, the boundaries of one proposed in the southern part of the State are indicated, and many of the present incorrectly marked lines have been placed in their proper positions.

The second, or large map, represents all the ground covered by the Survey, and is intended to show the positions of the coal openings, towns, county line crossings, and other points of interest; as well as a portion of the east and west parallel base line, the materials of which were kindly placed at my disposal by Mr. S. S. Lyon.

The elevations upon this map are shown by continuous horizontal contour lines, with intervals, representing 50 feet of vertical hight. The scale is three miles to the inch, being a reduction from the original plottings, upon a scale of 500 feet to the inch.

During the progress of the Survey specimens of coal, iron ore, and ther minerals, were collected, as also full suites of characteristic soils from the different geological horizons traversed. Attention was paid to the milling power, culture of the soil, pasture lands, and timber, a description of which, in detail, will be found under the head of the different counties.

DESCRIPTION OF THE COURSE OF THE OUTCROP BASE LINE.

In order to render intelligible the numerous references which it will be necessary to make in the Report, I will here describe the route of the

Survey, from its northern terminus, at the town of Grayson, in Carter county, to its southern terminus at the Tennessee State line. Leaving Grayson court-house, the line follows the Louisa road up the left bank of the Little Sandy river to the house of John H. Vincent; thence across to the Little fork of the Little Sandy, at the mouth of Straight creek, up the latter, passing the Mount Savage furnace, to the mouth of Gum branch, where it joins the detailed surveys of Greenup and Carter counties, made in 1856 and 1857, under the superintendence of Sidney S. Lyon.

Returning to Mr. Vincent's, the line continues up the Little Sandy to the mouth of Wolf creek, which it follows to its head, striking the river again at a school-house, near the forks of the road to Elliot's, and thence keeping up to the east of the river to the Rock Spring meeting-house, where it crosses; thence southwestwardly across Gimlet creek and Little Caney creek, at a point near its mouth, to Elliot's mill, on Big Caney; thence south to mouths of Laurel and Open forks, and up the latter to its head, crossing the Carter county line on the summit; thence down the North fork of the Licking river to the mouth of Bear run.

Returning to Grayson, a line was run from the court-house westward along the old turnpike to Olive Hill P. O., on Tygert's creek; thence up Tygert to its head, on the ridge dividing Carter from Rowan county; thence to Kirk's horse mill, and so up Christie's branch of Triplett creek to the ridge dividing the waters of Licking river from those of the Little Sandy; thence along this ridge, crossing into Morgan county, at the head of Judd Day's branch of Mince's fork, to John Nichols' house; thence in a southeast direction, crossing the Devil fork, to the head of Bear run, and so down the latter to its mouth, to join the main line. From here the line follows the North fork for a few miles, and then taking up the town branch, and down the Lick fork of Elk creek, strikes the Gill's mill and West Liberty road, at Cox's; thence westward to Hampton's mill, on the Licking river; thence across, and up Tom's, and down Barney's branch to Blackwater creek; thence in a due west course to the head waters of Brushy creek, in Bath county, where it enters the State road leading from Hazlegreen to Mount Sterling, and follows the latter to Jeffersonville, in Montgomery county; thence south across the head waters of Slate creek to Black creek, following the latter to its mouth, and entering Estill county, at the Red River Iron Works, from

whence it follows Red river to near the mouth of Hardwick's creek, and up the latter to the Estill steam furnace; thence down the Cow creek road to Irvine court-house and Estill Springs. Returning to the Estill furnace, the line takes along the Hazelgreen road in a southeasterly direction to the "Standing Rock," at the corners of Powell, Estill, and Owsley counties; thence along a ridge southwardly to the town of Proctor, on the Kentucky river; thence down the left bank of the river to the mouth of Sturgeon creek; up the latter to Samuel Brandenburg's; and thence along Brushy mountain to the Station Camp road at Elijah Hurd's; thence along the Manchester road and county line to Wild Dog creek, where it crosses into the new county of Jackson, and keeps around the heads of the War fork of Station Camp creek to the house of Thomas Carson, on the "Big Hill road," and on McCammon's branch of Laurel fork of Rockcastle; thence down the waters of Indian creek to McKee court-house, and so in a northeast direction to the top of the "Big Hill;" thence due south along the Madison State road to Wm. Golding's, where the line enters Rockcastle county, and follows the county road along the ridge dividing Indian and Brush creeks to Pleasant Fish's, on Roundstone creek; thence across and up Renfro's creek and Langford's branch to Mount Vernon court-house.

From Mount Vernon a line follows the Crab Orchard turnpike to the point where it crosses the Rockcastle river. From this line the main line takes off at a point near L. Langford's, and runs down the East fork of Skeggs' creek to H. McClure's, near the mouth of the West fork, whence another branch line descends the creek southeastward to the Rockcastle river. From H. McClure's house the line follows a county road, crossing the West fork at Mink's, and thence around the heads of Eagle creek and down Mill creek to Line creek, at the forks of the Crab Orchard, Somerset, and London roads, in Pulaski county; thence down Line creek to its mouth. Returning to the forks of the roads, it crosses in an easterly course to Sinking Valley, and thence to the cross roads at Dallas P. O., from which point it runs southeastwardly to a deserted cabin, at the head of Whetstone creek; thence southwest to the Bend meeting-house, in the valley of Buck creek, and so across to the Long Hollow; up the latter and down the Blazed Hollow to Pitman's creek, crossing it at G. Meece's, and thence down it to John B. Lee's, at the crossing of the Somerset and Coal Banks road; thence

along this road for six miles to the former place. Returning to Lee's, the line follows the right bank of the creek to John Beatty's, when it strikes over to Waitsboro', on the Cumberland river. Crossing the river at the lower ford, it runs southeast to Long's mill, on the Big south fork; thence southwardly across Cedar and Middle Sinking creeks, to the Three Forks of Big Sinking creek, in Wayne county; thence up the Dry fork to its head, and down a branch of Elk Spring creek to the Monticello and Rock creek road; thence along said road, in a northwest direction, to Monticello court-house. From here the line follows the Monticello and Albany road, crossing Beaver creek at Ard's ford, and Otter creek at Phillips' Mill, to John Wade's on Indian creek, in Clinton county; thence south, by the way of Wade's gap, to 'Squire Guinn's house, on Smith's creek, (from here a line was run southwest to Albany court-house,) and so across to James Givens, on the Livingston or Alabama stock road, in Spring creek valley; thence up the creek to Long's gap. Returning to Givens, the line runs due south through Elliott's cross roads to the Tennessee State line, at a point to the south of John Crouche's house, on the waters of Wolf river.

GENERAL GEOLOGICAL DESCRIPTION.

The traveler from Frankfort, directing his steps towards Virginia or North Carolina, by any of the great routes, will, after passing over the so called "blue-grass country," encounter a belt of cone-shaped hills, extending from the Ohio river southwestwardly towards Tennessee. These hills are often found in groups, familiarly known as the "Green River Knobs," "Estill Knobs," "Red River Knobs," &c., and are composed of the olive-colored shales and overlying grit stones of the Devonian system, known in the reports of this survey as the Knobstone Formation. They have for their bases the Devonian black slates, and are frequently capped with limestone—a fine instance being that of the Sweet Lick Knob, near the Estill Springs, rising to a height of more than five hundred feet above the Kentucky river, the outline of which, with that of many other knobs in the vicinity, gives a peculiar charm to the scenery of this portion of the State.

Having passed this line of knobs, the traveler has fairly entered the great Appalachian coal field. He passes over in succession the black slates, olive-colored shales and sandstones just mentioned, the sub-car-

boniferous limestones, the sub-conglomerate coal and iron ore series, and capping all, the massive conglomerate or millstone grit, which, in its turn, forms the true base of the coal measures which stretch on to the confines of Virginia.

This series of formations sinks towards the southeast in a great wave, the crest of which being broken off towards the northwest, presents that line of bluffs and hill-slopes which forms the commencement of the "mountain district" of Eastern Kentucky. But the crest line of this great wave, running northeast and southwest, is, itself, undulating, rising and falling in a series, as it were, of cross-waves of no great length and depth, but quite sufficient to determine the principal lines of drainage out from the mountain country to the plain.

Along the eroded crest of this great wave, the outcrop base line was run, not only defining thus the irregularly shaped margin of the coal field, but also supplying material for the construction of the profile which accompanies map No. 2, and represents a nearly straight line, extending from Grayson, in Carter county, to a point on the Tennessee State line, one half mile south of Elliott's cross-roads, in Clinton county. The base of this profile is equivalent to a height of four hundred feet above tide in the Gulf of Mexico. The same base was used in the construction of all the profile sections which appear in the detailed reports upon the counties.

The lowest formation which appears upon the main profile is that of the knobstone. The thickness of this rock varies between three hundred and fifty and five hundred and fifty feet, the measurements being approximate, as but few opportunities occurred for obtaining whole sections of the formation. The lower and larger portion is composed of olive-colored mud rock, with pretty generally disseminated nodular masses of earthy iron ore. From this horizon flow the numerous chalybeate springs of eastern Kentucky. The upper portion is a thin-bedded and generally fine-grained sandstone, also olive-tinted, containing, as a characteristic fossil, a cock-tail fucoid, similar in appearance to that of the caudi-galli grit formation of northern New York. Portions of this rock are valuable for building purposes; and from certain strata, fine-grained grindstones are obtained.

The streams which cut through this formation, flow in broad, flat-bottomed valleys, with gently sloping sides, and produce, during the first

few years of cultivation, such as is here in vogue, from seven to thirteen barrels of corn to the acre. It must be borne in mind that these bottoms receive the washings from the overlying limestones, and, also, that the above average yield will not hold good for the longer settled districts, as the system of farming is very imperfect, and little or no attention is paid to manuring or draining. It is upon these bottoms that the greater number of experiments have been made in the culture of sorghum, or Chinese sugar cane. Here, also, grows, in its greatest perfection, the sugar tree, which, with the other maples, the white oak, and the beech, make up the principal timber. The beech is found near the top of the formation, and only there when the neighboring hills are capped with limestone.

Next in order, above the knobstone formation, comes that of the subcarboniferous or mountain limestone, extending along the whole line, but thickening southwestwardly from seventy feet, on Tygert's creek, to over four hundred feet at the Poplar Mountain, in Clinton county. It is composed of alternating white, grey, and buff-colored layers of rock, varying in quality from the most argillaceous claystone to the purest plaster limestone. Clear and copious springs constantly mark the junction of this limestone formation with the underlying knobstone; and its lowest strata contain, in many places, large, dark-green flint pebbles, which, judging from present appearances, must have been extensively quarried by the Indians. Traces of lead are found through the center of this formation, but not in sufficient quantities to be of value.

The drainage through this formation is peculiar, and deserves more than a passing notice. The valleys are dish shaped, broad and shallow, and rarely have streams running through them; for the water issuing from the very numerous springs is carried down through sink-holes and cracks in the cavernous strata below, and often re-appears at the surface only to take another plunge before it gushes out at last in some never-failing spring, near the mouth of the valley. We have thus valleys which are technically dry, the bottom being a mere series of dry, crater-shaped holes, which, with proper treatment, may be made to supply with necessary water the cattle of this really admirable grazing portion of the mountain district of the State. To the topographer, however, no country could be more difficult to work over; and not unfrequently a stranger would be entirely at a loss to guess the direction of up stream from down.

The soil of the valleys just described is generally a tough clay mixed with sand, where the overlying millstone grit series forms the escarpments on each side; but it is not unusual to see large portions of the side slopes bare. As near as I could ascertain it, seven barrels to the acre is the average crop of corn for this formation, although land freshly broken up and properly tended will yield from ten to twelve barrels to the acre. Clover and other grasses thrive well, and could be made profitable, if taken in connection with cattle raising, upon the top lands overlooking these limestone valleys.

The timber is principally white oak and beech; but black, red, and post oak, together with red cedar, white walnut, poplar, buckeye, and hickory, are common. Pawpaw throughout, and the muscadine grape in the southern portion of the district, mark this formation.

Overlying the sub-carboniferous limestone comes the millstone grit formation, which may be described in two divisions, the lower of which is made up of alternating sandstones and shales inclosing beds of coal and iron ore, and the upper a massive, coarse-grained, ferruginous sand-rock, containing pebbles. This sand rock I shall hereafter, in this report, make mention of as *the conglomerate*, and the underlying strata as the *sub-conglomerate* coals, iron ores, &c. Though unexposed at the starting point of the section, I feel safe in saying that its entire thickness under the town of Grayson is not over ninety feet, a thickness which increases in the usual direction (S. W.) until it has become 305 feet in the Poplar mountain before mentioned. This, and the other formations with it, it must here be understood, not only *thicken* southwestwardly, but also *rise into the air* in that direction, as may be seen in the profile, where the top of the conglomerate, below Grayson, is five hundred feet above tide, whilst in the Poplar mountain it is seventeen hundred feet above tide.

The study of this millstone grit formation is of peculiar interest to the farmer, the geologist, and the civil engineer: to the farmer, because he may feed large flocks of sheep upon the table land above its cliffs and upon the rocky slopes below, which now lie waste, and thereby introduce a new and profitable culture requiring but little fencing or other labor; to the geologist, on account of its many changes in thickness and material; and to the engineer, because here he meets with his

greatest difficulty in the improvement of river navigation and in the construction of railways.

The two members of this formation thicken, as remarked above, in a southwest direction, but not proportionally, as I will now endeavor to show. At the northern end of the outcrop line, the conglomerate averages about 90 feet in thickness, and is underlaid by a few feet of somewhat ferruginous shales containing a thin coal; whilst upon the dividing ridge between Tygert and Triplett creeks, and the waters of the North Fork of Licking river, the former has attained a thickness of 150 feet, and is underlaid by eight feet of shale containing a well-defined bed of iron ore and a twelve inch vein of coal. To the east of this, on Devil Fork, the same vein of coal is five inches thick, whilst on one of the branches of Miner's Fork, the whole lower series is entirely gone; one hundred and forty-eight feet of the conglomerate resting immediately upon the sub-carboniferous limestone. Thin streaks of coal are jammed in between the layers of the base of the conglomerate, and even inlaid in the heart of the solid rock all along the line. In Estill county the sub-conglomerate series has attained a thickness of 50 feet, inclosing a workable bed of valuable iron ore and a vein of good coal twenty-seven inches in thickness. The conglomerate here measures 196 feet. To the east of this, at a point known as the Standing Rock, Mr. Lyon informs me that he found the upper member of this formation to be 210 feet thick, and the lower member 50 feet, consisting here of two feet of thin shaly sandstone, a one and a half inch vein of coal, and forty-eight feet of shales containing block and kidney ores.

Between this point, however, and the southern terminus of the line, a great change is seen to take place, the upper member nowhere now exceeding 80 feet in thickness, whilst the lower has increased to an average thickness of 225 feet, and contains two workable and three thin beds of coal, together with three distinct beds of shale containing iron ore. The point of change lies geographically between the top of the ridge dividing the Red river waters from those of the Kentucky river, and the valley of the Kentucky river itself. After a careful examination of this part of the line, especially of the ridge dividing Miller and Stufflebean from Hell creek, and also of the prongs of this ridge which lie between the waters of Sinking and Contrary creeks, I am not left in doubt that the lower portion of the upper or conglomeratic member

exchanges its character for that of an alternating mass of sandstone, shales, and shaly sandstones similar to, and therefore apparently increasing the thickness, of the lower member of the formation. The sub-conglomerate coal before mentioned holds its place at the base of the formation with the addition of later beds which came in above; and the whole is capped and protected by that unchanged upper part of the massive sand rock which appears upon the hill-tops and ridges of the Contrary creek waters in cliffs of 80 feet.

The upper or conglomerate member of the formation gives great character to the topography of the country, producing long, narrow, and steep-sided ridges, which give out at right angles similar narrow but shorter ridges, and these, in their turn, are fringed, as it were, with similarly formed still smaller fingers. Over this whole system of ridges along the eastern margin of the coal field lie, thinly spread, the lowest layers of the lower coal measures, in the midst of which the streams of the country take their rise. At first these waters flow along valleys smoothly cut in the coal rocks themselves, until the top of the conglomerate is reached, when suddenly, and usually with a single leap of from fifty to eighty feet, they plunge into gulfs worn out in the edges of this massive rock. Thenceforth they flow along between high natural walls until they reach the gently sloping terraces of the sub-conglomerate series, after which their way lies through the underlying limestones, knobstones, and black slates towards the comparatively level country beyond.

The soil of the millstone grit formation is poor, yielding, when first broken up, an average of only five barrels of corn to the acre, although this number has been increased to seven and eight in certain localities, and by careful cultivation can undoubtedly be made even more. Fruit grows admirably upon the slopes; and my attention was called to the fact, during the two seasons of our field work, that, unlike the fruit growing upon the lower limestone benches, it had here escaped the frosts.

The timber is varied, the principal kinds being chestnut and oak, with yellow poplar, linden, buckeye, spruce pine or hemlock, and yellow pine, with heavy underbrush of the same; holly, ivy, and laurel, and occasionally pawpaw. The pine grows immediately upon the top, and sometimes at the base of the conglomerate member. Laurel always fringes

the top edge of the bluffs. Holly and hemlock are found in the immediate debris of the cliff. The ivy climbs the rugged faces of the rocks. This is the characteristic vegetation of the conglomerate member of this formation as we traced it along the whole line, and found it only in this geological connection.

The next formation in the upper order is that of the true coal measures; but as the line passed along the thinned out edges of its lower members, there is little at present to be described in this report on that formation. It presents to the eye a surface contour of gently sloping hills, composed for the most part of ferruginous variegated shales, containing the mere thinned out edges of those coal veins, which to the southeast and east, become of such importance.

The portion of this formation above described is rich in forest trees of large growth, principally white oak, chestnut oak, and chestnut; the bark of the chesnut oak being valuable for tanning purposes; there are also red oak, mountain maple, dogwood, and poplar, the last being the principal wood used in the country for building. Yellow pine is common. White pine is not met with upon this geological horizon.

This ridge soil is poor; but its forests afford a thick crop of tender underbrush and mast, upon which large numbers of cattle and hogs are annually fattened for home consumption or the market.

From observations made during the progress of this Survey, the following deductions present themselves:

1. That the margin of the coal field is everywhere marked by bluffs of the conglomerate member of the millstone grit formation.

2. That the carboniferous formations and those underlying them dip to the southeast in a great wave, which is not symmetrically formed, as may be seen by referring to the profile sections of the counties—particularly those of Morgan and Pulaski.

3. That this great wave is itself crossed by undulations, which rise and fall in a series, as it were, of cross waves, of no great height and depth, but which, running, as they do, in a northeast and southwest direction, are quite sufficient to determine the principal lines of drainage out from the mountain country into the plain.

4. That all the formations examined along the line, from the Devonian black slates upward to the true coal measures, thicken and rise into the air in a southwest direction.

5. That the lowest coal, and, consequently, the one which marks the margin of the field, is a sub-conglomerate coal, varying in its thickness, but persistent throughout the whole extent of the line.

6. That certain species of trees mark certain geological formations; the beech and red cedar, for instance, being characteristic of the limestone series, whilst the hemlock, holly, and laurel, mark the conglomerate.

7. That the soil of this portion of the mountain district is not so rich as that of central Kentucky, yet is susceptible of great improvement, and that, in all the counties traversed by the outcrop base line, the proportion of fair tillable land is sufficient to supply the wants of a much larger farming and mining population than that which now exists; also, that the poorer slopes or ridge lands are admirably adapted to the raising of cattle and sheep; and in the southernmost counties the grape could be grown with success, especially if planted upon the warm limestone benches of the east and west valleys.

8. That the amount of mineral lying idle for want of the means of exportation is enormous, and deserves the particular attention of the iron manufacturer; also, that when the still greater mineral wealth lying beyond, in the heart of the coal and iron field, shall have been explored, by a continuation of the present survey, additional inducements will be offered for the development of this wealth; and that the numerous main roads running in an east-southeast direction through this field, afford excellent opportunities for such a survey.

CARTER COUNTY.

The drainage of this county is effected through the valleys of the Little Sandy river and Tygert's creek and their tributaries, which divide the county, in a manner, into three sections. The first and smallest lies to the east of the county seat, and is composed of the true coal measures, a description of which was given in Sidney S. Lyon's detailed report of the Greenup county survey. The second, or middle section, comprises the high lands lying between the two streams mentioned above, and contains the sub-conglomerate coal and iron ore beds. The third section, west of Tygert's creek, owes its topographical features mainly to the conglomerate, which caps the ridge dividing Carter from Rowan, and thus protects certain outliers of the sub-conglomerate coal. The southern line of the county follows a high water shed, the top of

which averages 1,400 feet above tide, and is formed of coal measure shales. In this water shed, the two streams before mentioned take their rise; the Little Sandy flowing along the general line of strike in an east of north course, cutting its bed down through the conglomerate along its whole length to near the Greenup county line; Tygert's creek flowing in the same direction mostly through the millstone grit, limestone, and knob formations. By a reference to the coal field map, it will be seen that about two thirds of the area of this county contains the lower coal bed, which, as far as my observation went, never exceeds twenty-two inches in thickness, and is frequently lost altogether; at no point does it present inducements for mining beyond the demands of a strict home consumption. This coal, with its thinned and overlying conglomerate, sinks under water level to form a canoe-shaped basin along the line of the Little Sandy river, about the center of which the now abandoned salt wells have been sunk. Grayson court-house stands near the north end of this basin, on the slope of a hill formed of the lower coal measure shales. Three distinct coal beds show themselves in this immediate vicinity; the lowest, which is the first above the conglomerate, crops out in the bed of the river just above the mouth of Stinson's creek. It measures six inches in thickness, and has been mined for blacksmithing purposes. Thirty-five feet above it is another bed, from six to eight inches thick, which I believe to be the equivalent of that which shows itself along the bed of Town branch, and which has been struck in Mr. Carter's well, at a depth of thirty feet below the surface. One hundred and four feet above it is a third, which has been opened by Robert Carter, Esq., in the hill to the northwest of the court-house. It presents itself as a double bed; that is, two bands of fair bituminous coal, each 18 inches thick, are separated by 29½ inches of shale, and they are probably the equivalents of the two members of the Stinson's creek cannel coal, though of inferior quality. (Six openings have been made in this Stinson's creek coal vein, at the head of Tar Kiln branch of Stinson's creek, which, at the time of my visit in October, 1858, were being actively worked.) An average section, made up from each, gives

	Feet.	Inches.
Bituminous coal	1	--------
Slate	--------	3
Inferior cannel coal	--------	9
Cannel coal	1	3

Specimens of both the upper and lower portions were sent to Dr. R. Peter for analysis. The lower, or good band, is that used in the manufacture of oil at one of the establishments in Ashland.

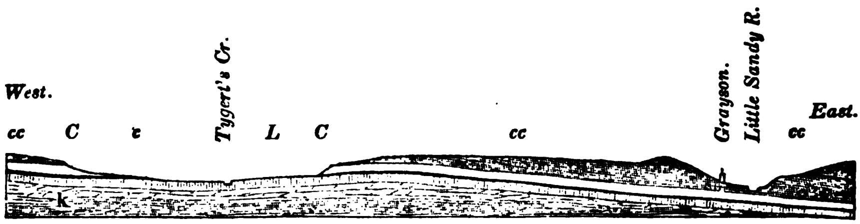
The following section will give a good idea of the stratification about Grayson:

		Feet.	Inches.
225 feet—	Top of hills, the upper 76 feet being covered—probably shales	76	--------
	Thin bedded, yellow, micaceous mud rock	4	--------
145 feet—	Bituminous coal	1	6
	Sandy micaceous shales, streaked with coal	1	5
	Yellow and ash colored mud rock	1	0½
	Bituminous coal, inclined to cannel at its top	1	6
	Covered space	59	--------
	Alternating shales and sandstones	20	--------
	Hard, dark-colored earthy limestone	1	--------
	Coarse yellow sandstone	4	--------
	Thin bedded micaceous sand rock	4	--------
	Compact, hard gray sandstone	5	--------
	Covered space—probably shales	7	--------
	Coarse, carbonaceous sandstone	4	--------
	Black slate, with stems	--------	6
35½ feet—	Coal worked in blacksmith shop	--------	7½
	Ash-colored shales	35	--------
0	Coal in bed of Little Sandy river	--------	6

The top of the conglomerate must be but a few feet below the river at Grayson; although at the first salt borings up the river it is 25 feet below the surface, and at the "Middle Lick," below the house of Doctor Lansdown, the probable center point of the canoe-shaped basin before mentioned, it is 50 feet below the surface.

The Carter coal vein shows itself near Ward's, to the west of the mouth of Straight creek; and the hills between the two, on the west side of the river, show terraces at the proper heights where it should come in; but none of the hills to the west of the river are high enough to take in the "Twin Coal" of Greenup county. The area of this bed west of the Little Sandy river must be necessarily small, inasmuch as the strata rise more rapidly than the streams, the evidence of which may be had along the route of our line towards Tygert's creek, where, upon the ridge

dividing that stream from Barrett's creek, the Poplar Plains road cuts into the sub-carboniferous limestone. The following section across the county will explain this more fully:



At the Tygerts' creek bridge the limestone just mentioned is seventy feet thick, and above, to the east, west, and southwest, are found constant indications of the sub-conglomerate iron ore dispersed through the shales which form the surface soil of this section of the country. Near J. James' house, on Barrett's creek, for instance, at a point where the limestone dips under the stream, a section is exposed, showing fifteen feet of calcareous shale, containing masses of earthy iron ore in seams. I was unable, however, to find any bed of it thick enough to work, though such may exist; in which case, should the Lexington and Big Sandy railway ever be completed, this will undoubtedly become an iron making region; and as a farming district it is unsurpassed by any in the county.

Above the bridge, and 1,800 feet below Rice's saw-mill, the bottom of the sub-carboniferous limestone, marked by flint pebbles, rises out of the creek, and the latter, from this point to the forks, a distance of over twelve miles, runs in the underlying knobstone.

In nearly every one of the valleys cutting into the western slope of the ridge which divides Little Sandy river from Tygert's creek, the sub-conglomerate coal has been seen, and in some few instances has been worked, always occurring immediately over the sub-carboniferous limestone, averaging not more than eight inches in thickness, and never exceeding twenty-two. This same vein has been worked by Mr. Pelfry, one mile below the head of Laurel Fork of Little Sandy river, where it is eight inches thick, and excellent for blacksmith's use. One half mile up Lick branch of Tygert, it is eighteen inches thick. It is in this

cc. Coal Measures. *C.* Conglomerate. *c.* Sub-conglomerate measures. *L.* Sub-carboniferous Limestone. *K.* Knob formation.

neighborhood, just above the house of Mr. Pelfry, that a fine spring issues from between the knobstone and limestone, the lower member of the latter being of a dead white color, and showing signs of lead ore. I was assured that at long intervals during the last forty years small quantities of that ore have been extracted. Although I heard of many such localities throughout the county, this was the only one I was able to find, as information respecting them is for the most part traditional, and jealously kept secret.

In connection with the vein of coal last mentioned the underlying iron ore is found, but not in any instance, when examined, was it present as a workable vein.

It will thus be seen that, although two thirds of the area of this county properly belongs to the coal field, yet the sub-conglomerate coal is only accessible upon the spurs that flank the valley of Tygert's creek, and upon the line of the Little Sandy river, between Laurel and Gimlet creeks; and also, that the true coal measures are confined entirely to that portion of the county lying east of the Little Sandy river, with the exception, as I mentioned before, of the lower workable bed, which does extend across that river, showing itself in the hills around and to the south of Grayson.

A large portion of Carter county is still in forest, particularly the two great water-shed ridges which run through it in a north and south direction, and are more or less inaccessible on account of the high bluffs of massive sandstone which underlie the coal measures. These hill-tops present few inducements to the farmer, who prefers the richer lands of the valley of Tygert's creek, where a broad bottom, cut out of the shales of the knobstone formation, yields ample crops of corn. The gently sloping sandstone and limestone terraces which flank this valley along nearly its whole length, afford also excellent grain and grass crops. The Little Sandy river, on the contrary, cuts its valley through the conglomerate, and winds between high cliffs from near its head to the region of the salt-works, where the valley widens and presents a warm, sandy, loamy, and pretty generally cultivated soil. I would here call attention to an indigenous growth of these bottoms. I refer to the cranberry, which, owing to the natural facilities of the country around Grayson, could be cultivated with success and profit, especially upon the lower of the two bottoms of the river, which could be flooded in the fall, after

sowing time, and thus remain until spring, when the water could be drawn off and the proper cultivation commence.

ROWAN COUNTY.

The outcrop of the coal field extends along the eastern edge and southern corner of this new county, covering a very small portion of its surface, in fact, embracing only the upper portion of the ridge dividing the waters of Tygert and Triplett creeks, and of the ridge between Christie's branch of Triplett and Miner's branch of the North Fork of Licking river. The drainage of the county is chiefly through the valleys of Triplett creek, and the eastern tributaries of Fox creek. These head up in the ridges before named, and flow into the Licking river through the sub-carboniferous limestone, knobstone, and black slates. The main body of the county may be said to be composed of the knob formation, the ridges being capped with limestone, and the main water courses exposing the underlying slates. The outcrop base line survey passes through the southeast corner of the county, mostly upon high ridge land, and presents the following traits: The top of the knobstone is first seen on the head waters of Triplett, near Kirk's horse mill, with 30 feet exposed of sub-carboniferous limestone over it, the lowest stratum of which is flinty. Above the limestone is a red clay, containing nodular iron ore. The coal bed coming next above, is wanting at this point, but further up the stream, near Sanford's store, a thin seam shows itself immediately under the yellow sand rock of the conglomerate member.

To the south of this, on Judd Day's branch of Miner's Fork, below the house of John C. Lykens, this sub-conglomerate coal is also wanting, one hundred and forty-eight feet of the massive sand rock, in a magnificent cliff, resting directly upon the limestone. But, at a point to the north of this, on Miner's Fork, the coal has been mined by Henry Upperhart 12 inches thick.

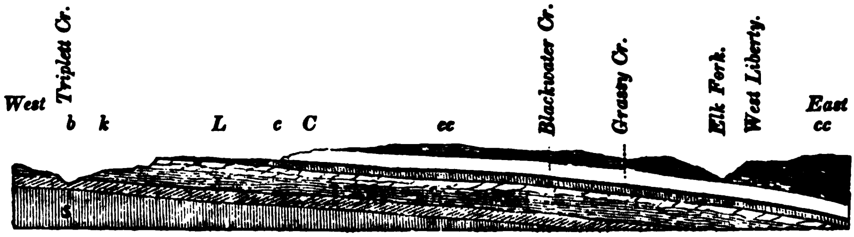
The ridges in this southeastern corner of the county are made by the conglomerate member of the millstone grit formation, covered with the lower ferruginous shales of the coal measures, which give to the tops of the ridges a peculiar potato-shaped form. In these shales I was able to trace, 70 feet above the conglomerate, a thin seam of coal, protected by a plate of sandstone, the undoubted equivalent of that coal bed which crops out in Town branch, near Grayson. None of these hills, however, are high enough to take in the low main bed of Grayson. The land in

this section of the county is poor, and gives the usual ridge timber of this formation—white oak, chestnut, and chestnut oak, with some few hemlocks, and a heavy undergrowth of the same, mingled with black jack. The following section shows the geology:

		Feet.
278 feet—	Shales, containing gravelly iron ore and a seam of coal 70 feet above the base	90
188 feet—	Conglomerate member of millstone grit	150
	Lower member, containing locally the sub-conglomerate coal and iron ore	8
	Sub-carboniferous limestone	30
0	Top of knobstone formation.	

MORGAN COUNTY.

The outcrop of the coal field is defined by an irregularly scolloped line, near the western boundaries of this county. It follows the contour lines of the ridge between Miner's and Devil forks, (crossing the latter at the intersection of the West Liberty and Morehead road,) and the dividing ridge between the North fork and the main Licking river; crosses the latter at a point half way between the mouths of Grassy and Blackwater creeks, and runs down the left bank of the river into Bath county, at the nose of the ridge between the river and Beaver creek. By reference to the map, it will be seen that nearly the whole area of the county is thus included in the coal field; although, perhaps, not more than one third of it may be said to contain the main coal beds above the conglomerate, which, as shown in the Report of 1857, (vol. 3, p. 158,) crop out in the vicinity of West Liberty. This is owing to the fact that that town lies in a basin very similar, no doubt, in shape, to that of the Little Sandy river; hence the coal beds which are found and mined upon Mordecai and Caney creeks, and upon the Elk fork of Licking, rise rapidly like the equivalent coal beds of Stinson's creek, in Carter county, towards the northwest, and are lost in the air, as is shown in the following section of the formation from West Liberty down the Licking river, across the western boundary of the county to Triplett creek, the mouth of which is in the Devonian black slates:



cc. Coal measures. *C*. Conglomerate. *c*. Sub-conglomerate measures. *L*. Sub-carboniferous Limestone. *k*. Knob formation. *b*. Devonian black slate. *s*. Upper Silurian rocks.

In order to define the outcrop of the sub-conglomerate coal, the base line was run too far to the westward to take in these cannel coals of West Liberty, which deserve a thorough examination in the future course of the survey. I would take occasion to say that the main road, which passes through this section of the State, is admirably adapted for getting a section of the rocks across the coal fields, its course being east southeast through Morgan and Floyd counties, and across Pike county, through Pikeville to the Virginia line—such a line would have the advantage of exposures along two rivers, the Licking and the West fork of the Big Sandy, and would cross and connect with the main east and west parallel base line just completed.

The sub-conglomerate coal, the outcrop of which has been now defined, is mined by stripping at many localities; measuring upon Miner's fork 12 inches, and at its crossing of Licking river one mile below Hampton's mill.

At a point on Devil fork I found it only 4½ inches thick, cropping out in the bed of the stream under the massive conglomerate, which here measures 140 feet in thickness. Wherever used, it has been found to be a good blacksmithing coal. In immediate connection with, and overlying it, such a streak of coal as has been before mentioned frequently shows itself, especially near the mouth of Perry's run, below Hampton's mill, where it averaged one half inch in thickness immediately underneath 50 feet cliffs of conglomerate. The same thing occurs at the road crossing Blackwater creek, where the coal measures 1¼ inches, and rests upon ash colored shales.

The second coal, above the conglomerate, shows itself upon our line near the house of William Kendall, in the bed of the North fork below the mouth of Bear run, where it measures twelve inches, and is protected by a capping of shales and shaly sandstones, containing impressions of Sigillaria and Calamites, and is based upon a hard sand rock. This coal can be traced all along the North fork from Bear run to the mouth of Town branch, and up the latter for a mile, where it measures 9 inches, having been opened by Mr. Kendall.

Crossing the ridge from this point to the Lick fork of Elk fork, it is again seen mined at several points near the house of Mr. Casby, where it has increased in thickness to 16 inches. This vein can be traced down the Lick fork to its junction, at Mr. Cox's, with the Big branch,

and also up the latter stream to near its head. The hills in this vicinity are, in some instances, high enough to take in the lower main cannel coal bed of West Liberty; but I could neither find nor hear of any outcrop. Judging from this circumstance, and from the visibly rapid dip of the strata southeastward, I am led to believe that no veins of workable coal will be found west of the ridge between Elk and Lick forks, and the ridge between Grassy and Caney creeks.

Below the house of Major Payton, and in the bed of Shoal branch, a 24 inch coal has once been worked, but is now abandoned. Farther down the stream, but still overlying the conglomerate, another opening, also abandoned and filled up, has been made; at both points the coal is overlaid with a mass of compact shaly sandstone, streaked with carbonaceous matter, and is probably the equivalent of the Casby vein.

On the south side of the Licking river there are indications of this same bed in Tom's branch of Grassy creek, near the school-house, and also in Barney's branch, above the house of Miles Kash, both resting upon ferruginous shales, and having for capping alternate layers of fossiliferous shaly sandstone and shales.

The sub-conglomerate iron ore is traceable along the outcrops of Morgan county, but nowhere showed itself on our line in workable quantities. Indications along Blackwater creek lead me to think that it may thicken in that direction, so as to become of value.

The western half of the county embodies the conglomerate member of the millstone grit formation, beneath rounded ridge cappings of soft ferruginous shales and shaly sandstones, over which are scattered farms, hemmed in by forests of white and chestnut oak, surrounded by precipices of conglomerate.

BATH COUNTY.

But a small portion of this county, viz: the southeast corner, is included in the coal area, and contains only the sub-conglomerate bed. Its outcrop may be defined as following the contour lines of the ridge which divides the head waters of Gilladie and Indian branches of Red river from the head waters of Beaver, Blackwater, Duck, and Salt Lick creeks, as far west as the head of Slate creek. In this county, for the first time, we met the sub-conglomerate coal as a double vein of workable thickness. Upon Clear creek there are "three feet of coal with a clay parting of one foot." It is principally mined near the head of Amet's

branch of Indian creek, where two openings, called the "Flower Hill Banks," have been made by Morris McCormick. When I visited this locality the lower opening showed a coal of fifteen inches in thickness. The same vein, with the same thickness, was opened further east, accompanied by a thin vein twelve feet above, and separated from it by shales. The old Flower Hill opening, 800 feet northwest of the first mentioned, and now filled with water, the dip being inward, is said to yield twenty-eight inches of solid coal. The "Tan-yard" and "Big" banks, owned by the same party, lie to the southeast, on another branch of Indian creek. The coal here I found to be two feet and nine inches in thickness, and about fifteen feet above the top of the sub-carboniferous limestone. The same bed has been lately opened still further east, and of about equal thickness, and perhaps better quality. The coal mined in this vicinity is used by the residents, who find it to be much cheaper than wood, though most of it is sent to Mount Sterling for blacksmithing purposes and the grate.

The sub-conglomerate ores of this county—the block and kidney ores underlying this coal bed—rest almost immediately upon the limestone, and are of sufficient thickness on Beaver creek to claim the attention of the iron-master; although at present the bad roads and the cliff-bound structure of the valleys, together with the total want of water navigation, are serious bars to success.

"The Dry Ridge," which forms the center of the mineral section of this county, attains, at the head of McCormick's branch, an elevation of 1300 feet above tide. I obtained here the following section:

	Feet.
325 feet—Top of Dry Ridge.	
Conglomerate member	100
225 feet—Sub-conglomerate member containing coal and iron veins	85
Sub-carboniferous limestone	140
0 feet—Top of knobstone formation, as seen just above McCormick's house	0

One well marked layer of the upper member of the millstone grit, a stratum of coarse, rose-colored sand rock easily disintegrated, may very well serve as a guide in searching for the sub-conglomerate coal, which lies about 60 to 70 feet below it.

The sharp summit of Dry Ridge carries the usual timber, although pine trees are more common here than along the northern end of the line. The old State road follows its crest, and the traveler has only to step to the right or left to find himself arrested at the edge of high precipitous cliffs, over which, at short intervals, plunge numberless waters,

wearing for themselves deep and narrow channels in the conglomerate. An interesting example of this is found at the Laurel Spring meeting-house, where the stream falls over a projecting ledge to a depth of 110 feet. Further east, Raccoon creek falls 41 feet down upon a shelving mass of the conglomerate, and then with another plunge of 44 feet reaches the bottom of the gulf. Instances of this kind are common, and though picturesque to the eye, present serious obstacles to the profitable working of the coal and iron beds which lie below these cliffs.

The valleys opening northward from this ridge deserve especial notice, as their streams, after quickly cutting through the conglomerate, flow along broad valleys in the limestone and olive shales of the knob formation, affording thus the only good farming land in this portion of the county. Particular attention was here paid to a collection of the soils; and careful analyses, made by Dr. Peter, show them to be of a better grade than those usually found in the same geological horizon. The side slopes of these valleys are beautifully terraced, and covered with a kind soil, which, with proper tillage, would yield 60 to 70 bushels of corn to the acre. Springs are abundant and of two kinds; one of cold hard water, issuing at the base of the limestone; the other a warm soft water, issuing higher up in the hills, and marking the place of the coal.

MONTGOMERY COUNTY.

The southern and western borders of this county lie along the crest of a ridge which encircles the head waters of Slate creek. The top of this ridge is formed of the conglomerate which protects the coal, the fringe-like outcrop of which overlooks the broad, knob-filled valley below. Its area is very small; but where opened up, it has proved to be of excellent quality; upon Petre-trace and Hawkins' branches, for example, where Mr. J. Wills has mined it for the Mount Sterling market. On the ridge between the two streams just named, I had a good opportunity of examining it; and from observations at other points I find it remaining in patches, protected by tower-like masses of the conglomerate, one of which, the "Pine Table," is conspicuous from a great distance. In Wills' "Hollow bank" the coal is double, the lower portion measuring eighteen inches, and the upper six, the two being separated by six feet of ash-colored shales. Across the ridge, to the southwest, is the "Cabin bank," now worked, where the coal appears in a single vein of twenty-four inches. One and a half miles to the north-

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One well marked layer of the upper member of the millstone grit, a stratum of coarse, rose-colored sand rock easily disintegrated, may very well serve as a guide in searching for the sub-conglomerate coal, which lies about 60 to 70 feet below it.

The sharp summit of Dry Ridge carries the usual timber, although pine trees are more common here than along the northern end of the line. The old State road follows its crest, and the traveler has only to step to the right or left to find himself arrested at the edge of high precipitous cliffs, over which, at short intervals, plunge numberless waters,

wearing for themselves deep and narrow channels in the conglomerate. An interesting example of this is found at the Laurel Spring meeting-house, where the stream falls over a projecting ledge to a depth of 110 feet. Further east, Raccoon creek falls 41 feet down upon a shelving mass of the conglomerate, and then with another plunge of 44 feet reaches the bottom of the gulf. Instances of this kind are common, and though picturesque to the eye, present serious obstacles to the profitable working of the coal and iron beds which lie below these cliffs.

The valleys opening northward from this ridge deserve especial notice, as their streams, after quickly cutting through the conglomerate, flow along broad valleys in the limestone and olive shales of the knob formation, affording thus the only good farming land in this portion of the county. Particular attention was here paid to a collection of the soils; and careful analyses, made by Dr. Peter, show them to be of a better grade than those usually found in the same geological horizon. The side slopes of these valleys are beautifully terraced, and covered with a kind soil, which, with proper tillage, would yield 60 to 70 bushels of corn to the acre. Springs are abundant and of two kinds; one of cold hard water, issuing at the base of the limestone; the other a warm soft water, issuing higher up in the hills, and marking the place of the coal.

MONTGOMERY COUNTY.

The southern and western borders of this county lie along the crest of a ridge which encircles the head waters of Slate creek. The top of this ridge is formed of the conglomerate which protects the coal, the fringe-like outcrop of which overlooks the broad, knob-filled valley below. Its area is very small; but where opened up, it has proved to be of excellent quality; upon Petre-trace and Hawkins' branches, for example, where Mr. J. Wills has mined it for the Mount Sterling market. On the ridge between the two streams just named, I had a good opportunity of examining it; and from observations at other points I find it remaining in patches, protected by tower-like masses of the conglomerate, one of which, the "Pine Table," is conspicuous from a great distance. In Wills' "Hollow bank" the coal is double, the lower portion measuring eighteen inches, and the upper six, the two being separated by six feet of ash-colored shales. Across the ridge, to the southwest, is the "Cabin bank," now worked, where the coal appears in a single vein of twenty-four inches. One and a half miles to the north-

east is the "Pine Table bank," where the coal measures twenty inches, with a thin vein above. Between this and the Cabin bank is another opening, showing a thickness of coal from eighteen to twenty-two inches. One and a half miles to the southeast of Wills' banks, Mr. Jas. Ballard has opened coal twenty inches thick. The coal is thinner here than at McCormick's, further east, and lies but a few feet above the limestone, and thirty-six feet under the conglomerate, showing thus a thinning also of the accompanying measures. The sub-conglomerate iron ore does not make its appearance here in any force.

The top of this boundary ridge produces fine chestnut and white oak trees; whilst the lower benches of the limestone show a growth of sugar tree, locust, buckeye, linden, and poplar, and yield about ten barrels of corn to the acre.

Slate creek drains this part of Montgomery county, cutting through the limestones, which measure about the same as on Beaver creek, and through the knobstone, which is 330 feet in thickness, into the black slates; then winding about in the latter until it enters Bath county. In its bed, opposite Mr. Willis' house, are exposed in the olive shales three distinct, thin beds of nodular iron ore, traceable for a long distance up the valley. Further down, after having passed into the black slates, black sulphur springs become common. A fine one issues near the forks of the road to Flute's mill, and another on Sycamore creek to the southwest of Jeffersonville, near the house of 'Squire Halley. The valley is broad, and studded with conical hills formed of the knobstone. These knobs border the southern line of the county, and occasionally, when capped with the conglomerate, attain a considerable height, as is the case with the "Pilot Knob," between Black and Lulbegrud creeks, remarkable for its millstone quarries.

POWELL COUNTY.

The northern limits of this county follow a ridge which runs nearly east and west, whilst the southern line follows one running in a northwest and southeast course, the two nearly meeting at the western end, to allow just room enough for the passage of Red river, which flows in a due west course through the entire length of the county. One half of its area is covered with the sub-conglomerate coal bed, the outcrop of which may be defined as following around the ridges lying to the north and south of the river, as far up as the mouth of Gilladie fork, below

which it crosses; more than half of the area of this coal bed is therefore under water level.

Red river, which, with its tributaries, drains the entire county, enters from Morgan county through cliffs of the conglomerate; runs westward through the sub-carboniferous limestone and knobstone, and encounters the Devonian black slates first near the forks. Through these it winds until it abruptly turns and breaks out of the county near the Red River Iron Works.

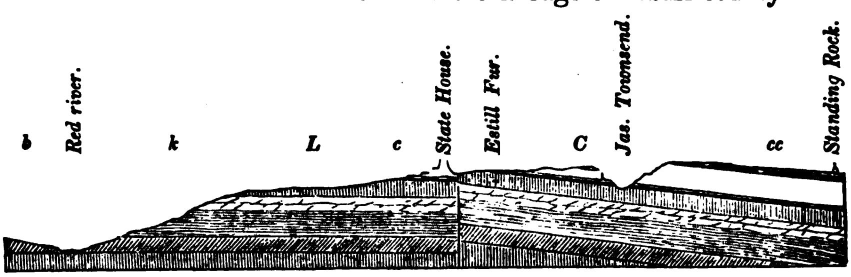
As the outcrop base line crosses merely the extreme western corner of the county, in the black slates, I had but little opportunity to examine the coal. Mr. Lyon, whose base line runs through the southern corner of the county, informs me that he found the coal near the head of Graining Block creek, and upon Little South fork, but only as a streak. Judging from its outcrops just over the line in Estill county, this thinning out is only local; for north of Red river the bed of the "Pine Table" and "Flower Hill" banks shows itself near the river, and is known to cross it at a point not far below the mouth of Gilladie creek. In the southwest corner, between the heads of Catamount and Hardwick's creeks, it has been opened and mined by J. W. Jones. It is here a double bed, as upon Indian creek. The following section shows its accompanying rocks:

		Feet.	Inches.
882 feet—	Top of "State House" rock.		
	Conglomerate member	196	
686 feet—	Shales and shaly sandstones	50	
	Hard black slate roofing	4	
	Coal	1	3
	Soft, dark grey shales	4	
	Coal	1	
	Shales, including block and kidney ore vein	15	
611 feet—	Sub-carboniferous limestone	161	
450 feet—	Knobstone formation	350	
100 feet—	Devonian black slate	100	
0	Bed of Red river.		

The rock known as the State House stands in the southwest corner of this county, one half mile northeast of the Estill steam furnace, and is a bold feature in the surrounding scenery, towering above all the hills in this region, and attaining an elevation of 1,464 feet above tide. A few hundred feet to the southeast of this rock occurs a down-throw, or fault, the general direction of which is with the strike of the great coal basin; that is, N. 30° E. As Mr. Lyon does not mention it as crossing the

east and west parallel base line, and as I could discover no signs of it north of Red river, I conclude that it extends but a few miles. The amount of down-throw may be measured along the iron road, leading out of Hardwick's creek to the furnace, where the top of the limestone formation is 1,216 feet above tide, whilst three eighths of a mile due south, near the furnace, it is 1,376 feet above tide, the difference being 160 feet.

The following section, carefully prepared from actual measurements and levels, will represent this local peculiarity; and, at the same time, the formations from the Standing Rock, at the east end of the county, to the State House Rock, and thence across the northern limb of Estill county to a point on Red river, near the mouth of Hardwick's creek. It will also answer for the extreme northern edge of Estill county:



The sub-conglomerate iron ore bed is well developed in the region just described, much of it having been used in the Estill steam furnace. It occurs in a compact layer, but sometimes also in kidneys, cemented with clay, and generally lies directly upon the sub-carboniferous limestone. It can be traced both to the north and south of Red river. To the eastward it seems to grow thin and uncertain. The nodular iron ore of the olive-colored shales is found also further up the river; but, owing to the dangers of navigation and the want of roads, neither the iron ore nor the coal can be profitably mined. These are serious drawbacks to the prosperity of this country. This county will not compare agriculturally with those bordering it on the southwest, west, and north; nor do its high cliff-bound table lands present so kind a soil; yet along a portion of its main water courses are to be found many broad bottoms, admirably adapted for the raising of sugar and Indian corn, whilst the limestone benches produce as well as in the other counties.

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b. Devonian black slates. *k*. Knob formation. *L*. Sub-carboniferous limestone. *c*. Sub-conglomerate measures. *C*. Conglomerate. *cc*. Coal measures.

ESTILL COUNTY.

By the recent setting off of Jackson county the coal area of Estill has been much reduced, being now confined chiefly to a narrow strip bordering on the south, west, and northeast. Its outcrop follows the contour lines of the ridge around the head waters of Miller's creek, on the north side of the Kentucky river, and the two short and narrow ridges between the Owsley line and Ross creek, and between the latter and Station Camp creek, on the south side of the river. Small detached areas occupy certain ridges around the heads of Red Lick, Middle, and Rock Lick forks. This coal bed has been opened at numerous points on the head waters of Miller's creek. At the Estill furnace it measures twenty-four inches, but thins away in an east direction. Its coal seems to be more highly esteemed by the blacksmiths where it is thinnest, for they are known to frequent openings at a great distance when a thicker and more conveniently worked bank is at their doors.

The iron ore underlying this coal seems to attain its maximum thickness in that portion of the county around the heads of Cow, Miller, White Oak, and Hardwick creeks, showing itself sometimes in the form of kidney ore, and sometimes in solid layers or blocks. The bed, varying from 7 to 24 inches, rests for the most part directly upon the sub-carboniferous limestone. Imbedded in the overlying shales is frequently found a twenty-four inch stratum of white quartzose sandstone, which may prove valuable for manufacturing glass.

To the presence of this ore, in connection with a partial river navigation and pretty fair roads, is due the erection of the furnaces which will be hereafter described, and which make the connecting link, as it were, between the great Hanging Rock iron region to the north, and the Tennessee iron making regions to the south and southwest. Lower in the series, especially along the valleys of White Oak and Cow creeks, large masses of nodular iron ore are disseminated through the lower portion of the olive shales of the knobstone formation; but in no instance yet known do these occur in sufficiently close contact to warrant the erection of iron works.

The limestone formation which caps the ridges in the vicinity just described, and which to the eastward is found under the conglomerate, becomes thicker and more cavernous than to the north. "Sinks" or potholes and caves are to be met with on every side. The first annoy the

farmer by carrying off the surface water under ground; and the miner by causing frequent ruptures in the ore beds, quite considerable areas of which disappear, being either lost or very difficult to reclaim. The caves are interesting as having, a half century ago, afforded shelter to the early settlers, who not unfrequently erected in them furnaces for the manufacture of saltpetre. The valleys in this formation are pretty generally settled and yield fair crops. The ridges flanking them are covered with chestnut, white oak, and pine, and afford good pasturage for cattle and for sheep.

Hardwick's creek flows for more than half its length through a broad valley cut out of the knob formation. Its sides are flanked with terraces of limestone, which give 8 to 10 barrels of corn and 10 to 12 bushels of wheat to the acre. For a mountain district, it is thickly settled, and much attention has been paid to the culture of the Chinese sugar cane, making a rich and cheap molasses, but with a greenish taste, because the cane is cut before it is fully ripe. It has been proved that if the stalks are allowed to become as yellow as those of the ordinary Indian corn, while the quantity of juice expressed may not be so great, a much superior article of commerce will be produced.*

In this valley coal has been bored for—the Devonian black slates having been mistaken for those belonging to the coal measures. In one of the borings the upper portion of the auger was blown out into the air by gas, and the lower so bent in the boring as to stop the work. At the head of the broad portion of the valley, Samuel T. Vaughn also sunk an auger to the depth of 405 feet, the result being a small but constant flow of petroleum. He reports having passed through, first 15 feet of surface soil, then 100 feet of black slate, then 100 feet of a light-colored earthy calcareous rock, followed by 190 feet of gray limestone, at the bottom of which the auger dropped into a cavity, and when withdrawn salt water was blown out for a short time, which soon gave place to the present flow of rock oil.

Above the mouth of this creek, in an abrupt bend of Red river, and in the extreme north end of the county, is the site of the first iron furnace built in this region. On account of its distance from the ore it was pulled down in 1831, and the present Estill steam furnace erected

* The lower portion of the valleys of Miller, Cow, and Station Camp creeks present the same advantages, and are also thickly settled.

in its stead. Here also a forge was built in the year 1810, and worked successively by T. Dye Owings, Mason & Gist, Jackson, Mason & Co., and Josiah A. Jackson. It is now owned and worked by the latter, and contains four fires and one hammer worked by water, and makes blooms from metal made at the Estill Furnace. The rolling mill attached to this forge, and owned by the same party, but now abandoned on account of the difficulty of obtaining stone coal, was erected in the year 1837 by Lawell, Jackson & Co., and contained 7 furnaces in all, 2 trains of rolls, and 5 nail machines, working up the blooms made in the forge into merchant bar iron and nails.

Estill Steam Furnace lies 10 miles S. S. E. from the forge, and was erected in 1830 by Mason, Wheeler & Co., rebuilt in 1849 by Lawell, Jackson & Co., and is now owned by Jackson & Jones—Mr. J. W. Jones being the resident manager. It is what is called a "quarter furnace;" has a capacity of 2,500 tons per annum; uses a cold blast, and makes pig metal from the ores found in the vicinity. The metal produced at this furnace chills to a depth of 1-16 inch in the pig, and is highly esteemed for the manufacture of railroad car wheels.

The Cottage Steam Furnace lies to the east of the last named, and was built in the year 1856 by Mason & Wheeler, and made in 1857 725 tons of metal from the sub-conglomerate gray carbonate ore of the region. It is a quarter furnace, and when in operation used a hot blast.

The Kentucky river flows in a west-northwest course through this county, dividing it into two nearly equal parts, and becomes, at certain seasons of the year, a highway along which the coals of Owsley county are transported to Lexington, Frankfort, and the ports along the Ohio. At the town of Irvine it fairly emerges from the mountain district, winding round the base of the Sweet Lick knob, and passing westward on through the comparatively level portions of the county, well described in Vol. III of the Reports.

In this county, as in others situated in the same geological position, occur numerous sulphur springs, the most noted of which are those near Irvine, issuing from the black slates at the base of the Sweet Lick knob, and described by Dr. Peter under the head of Nos. 601 and 602 of his report.

Besides these, there are three other distinct horizons: first, chalybeate springs issuing from the olive shales, and in immediate connection with

the deposits of nodular iron ore found everywhere in this formation; secondly, hard water springs gushing from caverns in and at the base of the sub-carboniferous limestone, and flowing over the grit stones of the knob formation; and thirdly, soft water springs in the shaly slopes under the conglomerate, good guides in tracing the sub-conglomerate coal bed. The so-called springs of the "sinking country" are merely the accumulated masses of these last, which, after flowing underground, re-issue from the caves of the underlying limestone, and frequently in sufficient force to be used as motive power for grinding grain.

OWSLEY COUNTY.

The whole of this county is included in the eastern coal field, with the exception of the lower portion of the valley of Sturgeon creek, and the valley of the Kentucky river, from the mouth of that stream to the Estill county line.

The lower member of the millstone grit formation is here increased in thickness, and goes under water level between the mouth of Contrary creek and a point three quarters of a mile above Proctor, thus leaving but a small area along the river from which to mine, though upon the streams to the west of Proctor, especially upon Sturgeon creek and its tributaries, the outcrop presents a wider field. These measures contain four, if not five, veins of coal, all of which have been found in the vicinity of Proctor, though but one has, as yet, received much attention from the miners. This one is known as the "main coal," and measures from 42 to 50 inches, and has been opened and mined as follows:

[illegible]'s lower river bank	[illegible] feet above tide.
[illegible]'s bank, on Mike's branch	[illegible] feet above tide.
Beatty's river banks	[illegible] feet above tide.
Beatty & [illegible]'s Lower Stufflebean banks, John G. McGuire's bank, on Upper Stufflebean creek	[illegible] feet above tide.
[illegible]'s bank, on Main river, above Proctor	[illegible] feet above tide.
A. McGuire's bank, on the South fork	[illegible] feet above tide.
Henry Smith's bank, on [illegible] fork	
[illegible]'s [illegible] bank, on Sturgeon creek.	

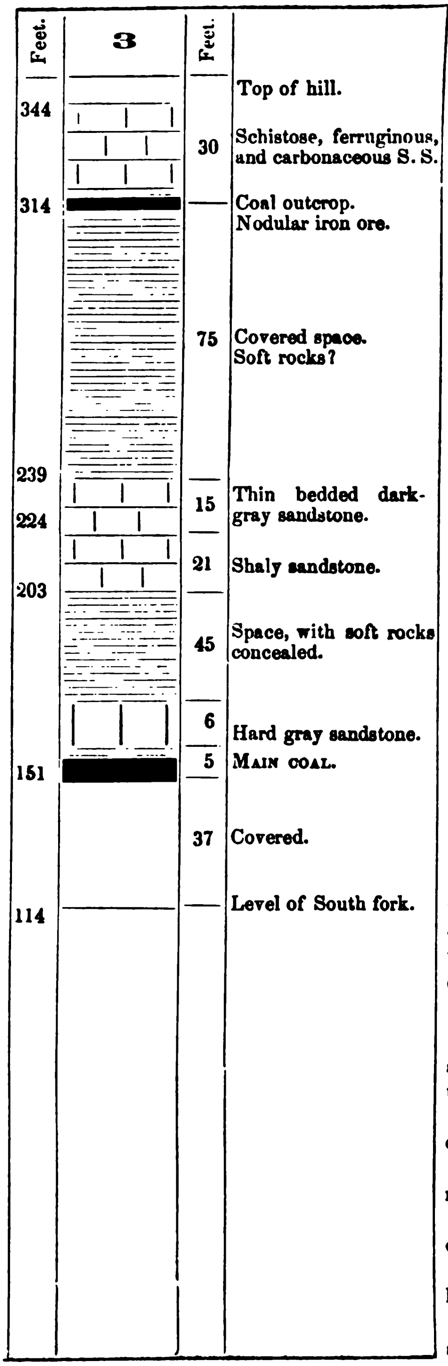
More or less trouble is experienced in mining this "main coal," alternately thinning and thickening, as it does, so that water settles in the gangways in pools. A local peculiarity of this vein here seems to be, that no matter where opened it dips for a short distance sharply into the hill and then obeys the general dip of the country, which, taken over a wide extent, I calculate at three fourths of a degree in a S. 52° E. direction. All gangways north of the Main river, near Proctor,

should be driven a little north of west, whilst upon the South fork they should be driven due west.

The coal is bright, and breaks with a square butt into fine large blocks, which bear transhipment. Specimens were collected for analysis. The vein is covered by a black shale bed, varying in thickness from one inch to four feet; but it has been really protected from erosion by a bed of massive gray sandstone, which, in every locality examined, was seen to overly it. In the shales, immediately above this last rock, is a stratum of iron nodules. Sixty feet below the "main coal" is a persistent mass of hard gray sandstone, with a bench, or terrace, both above and below it. These constitute good guides in searching for the main coal in this region, where no two sections can be obtained showing the same disposition of rocks, as may be seen by the following sections and their appended notes. No. 1 is reproduced from Vol. I, p. 216, of the Reports; No. 2 is a section of the rocks at Dudley's lower river banks, above the mouth of Contrary creek; and No. 3 is of the rocks at McGuire's bank, on the South fork:

Feet.	1	Feet.	
346		35	Yellow shaly (1) sandstone.
311		15	Schistose, ferruginous
		2	and carbonaceous S. S.
296		1½	COAL.
		20	Gray argill. shales.
		17	Space, with shaly rocks concealed.
		18	Bluish-gray shale, with car. of iron.
		40	Space, with rocks concealed in slope.
199		37	Shaly sandstone, thin bedded.
		8	Massive sandstone. (2)
			Black shale.
151		3.10	Main COAL.
			Black shale.
		35	Space, with soft rocks concealed in slope.
116		½	COAL and fire clay.
100		⅓	COAL and clay. (5)
		16	Hard sandstone, under bed of iron.

Feet.		Feet.	
250			Top of hill.
		19	Thin bedded gray S. S.
		20	Shaly sandstone.
211		25	Shaly sandstone.
			Ripple marked S. S.
		21	Shaly sandstone.
		6	Nodular iron ore shales
		4	Compact gray S. S.
		4	Black shale.
151		4	COAL. (6)
		30	Alternating sandstones and shales.
121		31	Ash-colored shales.
90		30	Sandstones. (3.)
		28	Covered space, with bench above and below—probably shaly sandstone.
32		29	Compact yellow sandstone.
		1	COAL. (4)
0			Black slate.
0			Sub-carboniferous limestone.



It will be seen by these that 150 feet above the main coal vein is another about 18 inches thick. It is found back from the river in those hills which are capped with the massive yellow sandstones of the conglomerate member. Below the main bed, and 35 to 40 feet over the hard gray sandstone above mentioned, occur locally two thin seams of coal close together; and still lower down in the series a third is to be found, 145 feet below the main bed, and just above the top of the sub-carboniferous limestone. This last mentioned does not exceed 12 inches in thickness in any of the numerous outcrops examined. On Sturgeon creek at its mouth, and also one mile above its mouth, this coal is underlaid with a two-inch vein of fire clay, the whole resting upon a fine grained black slate beautifully marked with Sigillaria. This slate has been mistaken and mined for cannel coal. Nodules of iron ore

(1) This rock attains a thickness of 80 feet, and forms the capping of the ridges back from the river.

(2) This rock is a single stratum of 12 feet, over Beatty & Blount's opening.

(3) At Beatty's river banks the top of this rock is 76 feet below the coal.

(4) This coal shows itself on Contrary creek, 15 feet above the L. S.

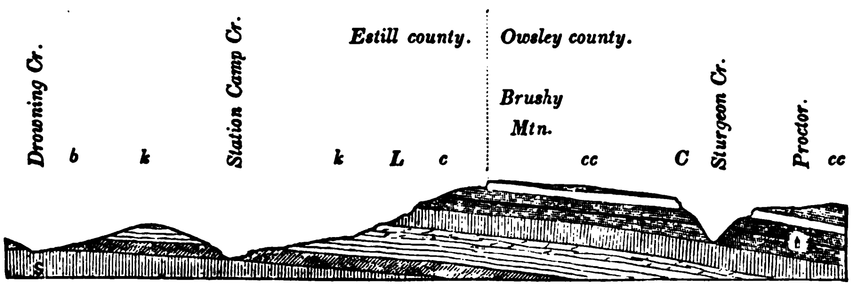
(5) A 2-inch vein of coal occurs on same level one mile up Contrary creek.

(5) This coal is 150 feet above the L. S. at a point one mile up Sturgeon.

are disseminated through the thin beds of shales which lie above and below this coal. Thin beds of carbonate of iron have been found in connection with the main coal bed, and nodules of the same occur under the upper coal; but at none of these three horizons could I find iron ore in workable masses.

Proctor lies in one of the cross waves of the coal field, and the sub-conglomerate member of the millstone grit formation seems here to have attained its greatest thickness, measuring 296 feet. To the N. E. in the ridge between the Stufflebeans and Miller's creek, it measures 195 feet, whilst in Powell county it is reduced to 85 feet. The upper or conglomerate member, however, increases in the same direction, from about 60 feet, near Proctor, to 90 feet on Miller's creek, and 196 feet at the State House Rock in Powell county, thus keeping the thickness of the whole the same throughout, in spite of the great changes in both its members. On the west crest of Brush mountain, in the southwest corner of the county, the covered slopes between the top of the limestone and the conglomerate measure 211 feet, and the conglomerate member itself is 82 feet thick, and forms the base of the surface soil of all that region.

The limestone on this part of our line has also increased to 191 feet in thickness. From these measurements, and others obtained down the Kentucky river, I am able to present the following profile section, extending from Proctor in a west course, across Sturgeon creek and Brushy mountain, to the county line, and thence into Estill county across Station Camp and Drowning creeks:



The drainage of the county is through the North, Middle, and South forks, which meet near Proctor and flow into Estill county through the

b. Devonian black slates. *s*. Upper Silurian rocks. *k*. Knob formation. *L*. Sub-carboniferous limestone. *c*. Sub-conglomerate measures. *cc*. Coal measures. *C*. Conglomerate.

valley of the main Kentucky river. These streams cut deep, and the western portion of the county is mostly high ridge land, the Brushy mountain attaining an elevation of 1,300 feet above tide. North of the river the timber is large; oak, chestnut, mountain maple, with some pine and dogwood, being the principal growth.

JACKSON COUNTY.

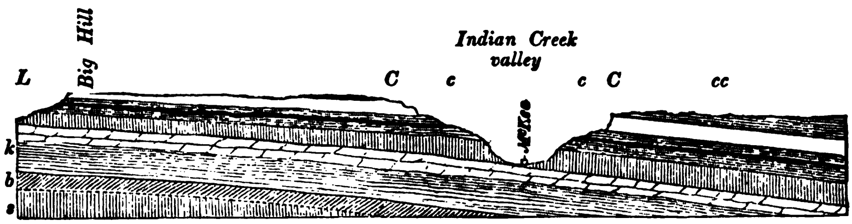
This county was erected in 1858 out of portions of Estill, Owsley, Laurel, Rockcastle, and Madison, and its general boundary may be described as follows: Commencing at the "Big Hill," it follows the Madison turnpike to the Rockcastle river; thence up the river to the mouth of Moore's creek and across to Terrel's creek, up the latter to the Gap between Sexton's Island and Sturgeon creeks; and thence along the road leading from Manchester to Irvine, to Station Camp creek; thence in a south of west course between Red and Rock Lick forks of Station Camp creek to the ridge dividing the former from the South fork; and thence along that ridge south-southwest to the point of starting, near Robert Cox's, on the Big Hill.

The whole county may be said to occupy that portion of the high land between the Kentucky and Cumberland rivers drained by the head waters of Station Camp and Sturgeon creeks northward, and by those of the Rockcastle river flowing southward.

Its county seat, McKee, is situated in Indian Creek valley, near the mouth of Birch Lick fork, and has an elevation of 1,040 feet above tide; whilst the "Big Hill," in the western corner, is, perhaps, the highest point, being 1554 feet above tide.

The surface soil is, for the most part, composed of the ferruginous shales immediately overlying the conglomerate, but in the southwestern part of the county the streams which are cut in the limestone open broad and productive valleys. In the extreme north of the county this latter formation is cut entirely through, presenting its stratum edges in bluffs, so that Rock Lick and a portion of War fork flow in the upper member of the knobstone along valleys as fertile as, or even more fertile, than those above.

The following presents a section profile of the county:



The sub-conglomerate coals extend over the whole county, except where cut out by the water courses just mentioned. Fully one third of its area, however, is, at present, practicable only by shafting, since the coals are under water level. The eastern portion has not been examined; but I am inclined to think that the upper, or Goose creek coals, may be found in the hills separating Sturgeon waters from those of the main South fork.

To the northeastward, on the heads of Granny Dismal, and Wild Dog, the lowest coal of the true coal measures is frequently met with, very thin throughout, averaging, where examined, about 4 inches, and lying in darkish fossiliferous, sandy shales, with a roofing of black ferruginous shales, measuring 12 inches in thickness.

The ridges in this vicinity are broad and flat, and grow the largest yellow pine yet seen along the line.

From the dividing ridge between War fork and Laurel fork, the line pitches down into Indian creek, where it first strikes the main coal vein of the county. This coal has in no instance been fairly opened, and is very imperfectly stripped, so that its real thickness and quality is hardly known.

On the Bee branch of Indian creek its outcrop measures 18 inches. In Bill's branch of Indian, one and a half miles north of McKee, it has been scraped out from under its sandstone capping to a depth of 14 inches, and proves to be an excellent coal. Appearances in the vicinity induced me to believe that this coal would increase very much in thickness under the neighboring hills. It lies about 150 feet under the sandstone bluffs capping the ridge, and about 60 feet above the limestone. To the northwest of McKee, on Birch Lick creek, near the house of James Isaacs, it lies 60 feet above the limestone, and measures $2\frac{1}{2}$ feet in thick-

cc. Coal measures. *C*. Conglomerate. *c*. Sub-conglomerate measures. *L*. Sub-carboniferous limestone. *k*. Knob formation. *b*. Devonian black slates. *s*. Upper Silurian rocks

ness—the upper 2 inches being impure—and is imbedded in bluish ferruginous sha'e, 6 feet of which underlies a 16 inch band of hard sand rock. It has again been opened by Mr. H. Sloan, on the same stream, further up, where it measures 2 feet in thickness, and presents the same peculiarities as at the Isaac's bank. Through this whole region a well pronounced terrace marks the place of this coal. Its outcrop has a rather sulphurous appearance, which the bed will probably lose when worked. This same bed has been found cropping out in the valleys on the other side of the long ridge, which lies to the north of this county. The rocks in this region all dip to the southeast.

Up the Clover Bottom waters, in the ridge, the bed measures 30 inches thick, with the same characteristics: an impure upper portion, and an overlying hard band of sandstone; but the accompanying shales contain more iron ore.

At the Big Hill there appears to be a thinning out of the coal measures, the main bed also coming to a knife edge; but the iron ore at this point shows itself in greater force. Below William Golding's house, for instance, along the slopes overlooking Horse Lick waters, a distinctly marked horizon is easily traced by large and numerous masses of carbonate ore lying in a band on the surface.

Beech timber attains a large size in all the valleys cut in the limestone, and the laurel thickets mark, as usual, the face of massive sandstone which bluffs out near the tops of all the ridges.

ROCKCASTLE COUNTY.

This county may be divided into two equal portions; the western half being formed of long rolling ridges of the sub-carboniferous limestone, and the conical hills of the knob formation; whilst the eastern half, as can be seen in map No. 1, is composed of islands (so to speak) of the coal measures, which lie out from the shore of the great coal field. These outliers are protected by patches of conglomerate, forming the tops of ridges which lie between the western tributaries of the Rockcastle river, all of them cutting down into the sub-carboniferous limestone. The general dip of the rocks is to the southeast; so that the streams, which flow *westwardly* into the river, cut very little into the limestone. The line of the Rockcastle river is, therefore, the true edge of the solid coal field.

The millstone grit and sub-carboniferous formations of this county

obey the general law of thickening along the southeast line of strike; and thin away northwestwardly from the Rockcastle river towards the outer limits of the coal field, as will be clearly shown.

The conglomerate member, which, in the southeast, is 80 feet thick, thins out towards the head of Roundstone creek. Along the ridge dividing it from the Kentucky river waters, nothing remains of it but detached masses or thin plates, which lie immediately upon, or but a few feet above, the limestone. A remarkable number of holes here occur in this rock, to be accounted for only by reference to the cavernous character of the underlying limestones. On Roundstone creek, six miles above its mouth, a quarry has been opened into this rock, which was formerly extensively worked for millstones.

The sub-conglomerate member, with its coal beds, seems to obey the same law; for on Skeggs' and Eagle creeks, and on the Rockcastle river, near the mouth of Roundstone, it measures 240 feet; whilst on the ridge, at the head of Brush fork of Roundstone, it has decreased to 102 feet; and still further to the northwest, on the ridge near the Mullin place, on the Scaffold Cane road, it measures but 40 feet in thickness.

At the point last mentioned, I found the sub-carboniferous limestone 115 feet thick; in the ridge to the south of Reed's tannery, on Clear creek, 145 feet; whilst on Roundstone creek it is 152 feet, and at Mt. Vernon 182 feet thick. From measurements made in the adjoining county, I have reason to believe it attains a thickness of from 220 to 240 feet in the southeast corner of this county.

The cavernous member of this limestone occurs about 100 feet below the top of the formation, and, where exposed by the erosion of the valleys, it swallows up the waters which come in from the neighboring hillsides only to yield them up again at the mouths of lower caves, or in powerful springs at the very base of the formation, at its junction with the knobstone; a fine instance of which is seen in Langford's branch below Mount Vernon. There is a higher level, 50 or 60 feet above this, where springs are common, issuing from a fine grained, white lime rock, much esteemed in this and the adjoining counties for burning. The Main street of Mount Vernon, (1,156 feet above tide, opposite the court-house,) is upon this stratum, locally known as the Marble limestone. At this level spread out wide terraces, over which are scattered the farms

of this portion of the county. Below this level the limestone shows at times a semi-oolitic structure; and where I examined it on Renfro's creek, it was accompanied by a red streak. In the valley of this stream, and in Roundstone creek, are to be found great numbers of geodes, containing quartz. Their place in the rocks I could not satisfactorily determine, although it is probably no great distance above the Marble limestone.

The next lower formation occurs at many points upon our line; but being mostly beneath the drainage level of the country, it was impossible to get its thickness.

The upper portion of the knobstone in this county is in thin olive-colored layers, of a fine compact grain, well suited for building stone. Grindstones are often made of them.

The coal bed of this county that has been most worked covers but a portion of the area described as belonging to the coal measures, and it is only in the eastern parts, bordering on the Rockcastle river, that it may be looked for as sufficiently thick to be worked with profit. Even there the want of good roads will be a serious drawback, as the river affords no facilities for transportation. In fact, navigation is impossible at such points as at the Narrows, so long as vast blocks of the conglomerate are permitted to keep undisputed possession of its bed.

This coal, as in Jackson county, has not been mined, but only stripped. Upon the nose of the ridge, between Clear and Brush creeks, it was found, by Mr. Langford, to measure 33 inches, with a sulphurous bench, four inches thick, running through the middle; it has a six feet capping of shale, upon which rests a ten-inch band of extremely hard rock. One mile south from Mt. Vernon it has also been opened upon the farm of Charles A. Ledd, who reports it to be a good coal, of 29 inches in thickness. In Graves' Hollow, branch of Skeggs' creek, it has been mined by C. Jones; but, owing to the bank having fallen in, I was unable to obtain its thickness. It lies here 80 feet above the limestone, and has been also opened in many places on the West fork of Skeggs' creek; but all the banks examined were found caved in; and, in fact, in no instance could I form a correct judgment of either the real thickness of the bed or of its quality, for it was never mined far enough in to get past the impure "tailings."

Above Henry Mullins', on Taylor's Spring branch, and near the top

of the ridge, a bed of coal, measuring 39 inches, has been struck, with a black slate floor and roofing. This is unlike the others, and higher up above the limestone, and may be the equivalent of the main coal of Proctor; but there are not sufficient proofs to establish the fact.

The lower small vein, just above the limestone, can be traced along nearly the whole extent of the line. In the hill east of Mount Vernon it appears in connection with a chalybeate spring.

Agriculturally speaking, this county is more favored than its north-eastern neighbors, inasmuch as the fertile limestone terraces spread over a greater portion of it; and the valleys, being often cut in the shales of the underlying olive shales, are, consequently, broad, and present facilities for lowland culture impossible in the higher formations.

I noticed one fact in regard to the high ridge land, which I think worthy of remark, viz: that the fruit trees in the numerous small orchards had not been injured like those in the lowlands by the unusally late frost of the present year.

Sugar trees and hickory abound all along the limestone valleys, as well as some beech. The heavier growth of the ridge land would be very valuable were the river cleared of obstructions for its transit to a market.

PULASKI COUNTY.

This is the largest of the counties traversed by the outcrop base line; and one half of it is coal measures—divisible into three districts. The first lies between the Cumberland river and the Big South fork, locally known as the "Texas District." The second, and, at present, most important of the three, is circumscribed by the contour lines of a system of ridges filling up the space between Rockcastle river, Cumberland river, Buck creek, and Sinking Valley. The last mentioned valley, strangely enough, does not appear at all on the map of Kentucky, although it is near twenty miles in length. Its course is nearly due south, to the east of, and parallel with, Brush fork of Buck creek, into the latter of which it empties, a few miles above the crossing of the Somerset and salt works road. The third district occupies a small, irregularly shaped area between Pitman and Buck creeks, and between the Cumberland river and the road leading from Somerset to London.

The average thickness of the sub-conglomerate member of the millstone grit formation, in the second of these districts, is about 200 feet.

At McKee's mines it reaches 233 feet. Further west it is 191 feet thick. It contains five beds of coal, two of which are workable, the lower being known as the "McKee vein," and the upper as the "Main vein."

The dip of the rocks continues to be, as in Rockcastle county, to the southeast. This is shown best by the fact that the top of the limestone is 102 feet above the river, at the mouth of Roundstone creek, in Rockcastle county; but by the time it goes down to the mouth of the river it is but just above the water level. This portion of the county is, therefore, fortunate in having its coal beds near the river for transportation, and so situated that they can be entered by the miner on all three sides of the area—upon the waters of both rivers, and upon those of Buck creek. This is particularly noticeable in the comparatively small space between the mouths of Buck creek and Rockcastle river, where no less than fourteen streams cut through both beds and afford ample facilities for the construction of cheap tramways down to the landings.

The lowest of these five beds, lying about 27 feet above the top of the limestone, is thin.

The second, in ascending order, varies in height above the limestone from 80 to 93 feet, and is irregular in thickness. An opening has been made in it by Alexander McKee, at the point of a nose between two branches of main Big Lick creek, one and a half miles back from the river, down to which latter runs an iron railway. It is a double bed, and has a clay parting, which thins as it enters the body of the hill. The bed shows an outcrop of from one and a half to three feet; but at the McKee mines I measured, in the left hand gangway, four feet six inches of coal, with a clay parting of thirty inches. In the right hand gangway a mere streak of clay separates one foot of an upper bench from three feet nine inches of a lower bench, permitting the miner to take out four feet nine inches of coal. As to the continuance of this thickness of the bed throughout the entire area, I was unable to form an opinion, as it has been thoroughly opened with a view to transportation only at the Nashville company's mines, above mentioned.

It is to be remarked that this double bed on the Cumberland corresponds, in its height above the limestone, with the two thin beds, one of six and the other of four inches, which occur on the Kentucky river above Proctor, and which are noted in Vol. I, p. 216, of this Survey;

and, also, that the "Main coal" of the Cumberland is at the same height above the limestone as the main vein of Proctor.

The third coal bed, which varies in thickness from six to twelve inches, comes in 40 feet above the double bed last described, or 125 feet above the limestone.

The main bed of this region, 25 feet above the last, or 150 feet above the limestone, has been opened in many places, and varies in thickness from 39 to 54 inches. About 50 inches seems to be the usual thickness in the mines examined.

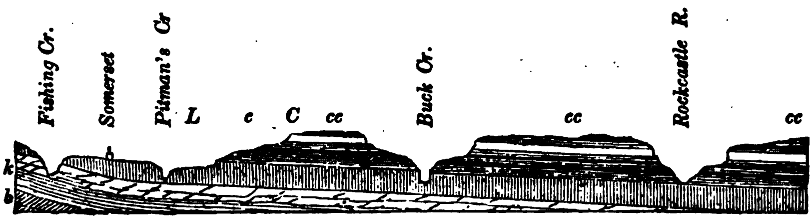
The fifth bed occurs about 15 to 20 feet above the last named, and is found in connection with the iron ore described on p. 235 of Vol. I of the Survey.

The base of the conglomerate lies 25 feet above this. It measures about 80 feet in thickness, and, for the most part, forms, in this portion of the country, the capping of the ridges; but immediately overlooking the Rockcastle river, it is covered with a sufficient quantity of the shales of the true coal measures to take in a 3½ to 4 feet vein of coal.

There are three distinct beds of shale containing iron ore traceable in the hills on the Cumberland river and upon the route of the outcrop base line, which, in this county, skirts the western margin of the coal. The first of these, a gravelly ore, shows itself under the lowest coal, and from 15 to 20 feet above the limestone. The second lies about 10 feet above the McKee vein, or 90 feet above the limestone; on main Big Lick creek, just above Mr. McKee's house, it shows itself in kidney-shaped masses, weighing from 1 to 35 pounds, and embedded in a gray shale stratum 5 feet thick. Two analyses show this to be a thirty per centum ore, containing sufficient calcareous matter to flux itself. The third ore bed lies near the base of the conglomerate, and will probably prove to be the most productive. There are also indications of an earthy iron ore just above the main coal bed; such, for instance, as that over the Sear's bank in the Pitman Hills, and the 9 inches band showing itself just above the Widow Pointer's house, at the head of No Name branch of Line creek. Below the house a 12 inches coal vein has been opened by J. Burdine, which, from its accompanying kidney ore, and from its height above the limestone, I judge to be the equivalent of the third coal bed. The same coal bed has been opened in the ridge dividing the Clifty's from Whetstone creek, where it measured 9 to 10 inches.

Indications of the McKee coal bed are found in the northern end of the Pitman Hills, in the heads of Blazed and Long Hollows, and the streams running into Buck creek.

The probable equivalent of the main bed has been opened in the hills 1⅜ miles S. of E. from Collier's Mill, on Pitman's creek. It lies 152 feet above the limestone, and near the crest of the ridge overlooking Buck creek. When worked, it measured 39 inches, with a clay parting. The bed will be found to exist and yield well on both sides of the Pitman Hills, furnishing a bountiful supply of fuel to the thickly populated districts to the west and northwest, which, in fact, must draw their contingent from this region, as no coal of any account can be found west of Pitman's creek, owing to the rapid rise of all the strata northwestward, as seen in the following section, made from the junction of the Cumberland and Laurel rivers to Fishing creek, through the village of Somerset:



The sudden increase of dip can be plainly seen on the river, to the south of the county seat; for the whole 150 feet of knobstone, exposed at Waitsboro', goes under water, at the mouth of Pitman's creek, in a distance of only two miles. In like manner, the lower portion of the overlying limestone, at Pitman's creek, forms the tops of the high hills between Somerset and Fishing creek.

Pulaski county, considering the great extent of its good farming land, based upon the limestone and knobstone formations, and the breadth of its mineral area, and its valuable forest timber—stands among the very first of the counties of the mountain district. At present, this whole region is nearly inaccessible: as the rivers, which would otherwise be highways for the exportation of its productions, are not, and can not be put, in navigable order, until the huge masses of conglomerate, which lock up the Big South fork and Rockcastle river, are blown away, and

cc. Coal measures. *C*. Conglomerate. *c*. Sub-conglomerate measures. *L*. Sub-carboniferous Limestone. *k*. Knob formation. *b*. Devonian black slates.

something is done to circumvent the dangerous shoals which obstruct the main Cumberland river and retard the development of its coal banks.

The proposed railroad, to connect Lexington, Frankfort, and Cincinnati with the rich valleys of Eastern Tennessee, if carried through the rolling limestone portion of Pulaski county, could cross with comparatively little difficulty the Cumberland river just below the coal, and there, gaining the ridge which runs through the Texas District, could be carried over a nearly level country to the eastern slopes of the Cumberland mountains overlooking Knoxville. This would, at once, bring the coal into market, and open up the valuable white pine lands which border on Tennessee, and also the red cedar lands to the north of them.

The limestone formation continues to thicken through this county southwestwardly, measuring 250 feet at two points on Buck creek, and 242 feet in the Long Hollow. Through it is cut the long, dish-shaped Sinking Valley, with side slopes yielding fine crops of blue grass and grain. The upper portion of Buck creek, also, runs in this formation, but passes into the underlying knobstones just above the crossing of the salt works road. Pitman's creek runs in it to its mouth. These last two streams furnish admirable milling power; and the introduction upon them, within the last few years, of the finer kinds of millstones, has given a wonderful impetus to the farming interests of the neighborhood. Now that wheat can be properly ground, and so made profitable at a distance, the old system of an endless succession of crops has given way to the more healthful alternation of deep-rooted grasses and grains, improving the worn out lands, and increasing their money value; while another and remoter consequence is seen in a more attentive and successful sheep raising.

WAYNE COUNTY.

One half of the area of this county is embraced within the coal field, which contains not only the five sub-conglomerate coals, but in the extreme southeast corner the large beds of the upper coal measures are said to show themselves. Like that of Pulaski, its coal area may be divided into three districts; one, embracing all that high ridge land lying between the Big and Little South forks and the Tennessee State line; a second, the ridges lying between the waters of the Sinking creeks, on the east, and the Elk Spring and Kennedy's creeks, on the

west; and a third, the high lands between Elk Spring creek and the Little South fork, and between Otter and Beaver creeks.

As yet, the main coal bed of the Cumberland river district is the only one which has received attention, openings in it having been made along the Big South fork, and in the ridge at the head of Fall and Big Sinking creeks; but at only two of these points are the mines now worked.

Ascending the Big South fork, the Dodson mines come first, high above the river, near the summit of the nose projecting between the South fork and Big Sinking creek, lying 160 feet above the limestone, and said to average 46 inches in thickness. It is a sulphurous coal, embedded between three feet of shale below it, containing an earthy iron ore, and three feet of shale above it, capped with a three feet band of hard gray fossiliferous sand rock, very similar in appearance to that found overlying the main Proctor bed. Over this is 20 to 30 feet of shale, forming the top of the ridge, which is strewn with iron ore. At the same geological level across the river, the ferruginous shales are *reported* to contain an amount of ore equal to a thirty-six inch vein.

One hundred feet below this coal bed, and seventy-one above the limestone, is the outcrop of another, which is probably the equivalent of the McKee bed, and which is said to be three feet thick.

Thirty-three feet below this last, and twenty-eight feet above the limestone, is the small coal bed found elsewhere in this position.

The main bed can be traced from Dodson's all along the ridges dividing Big Sinking, Turkey creek, and Long branch; and in the ridge dividing the latter from Little South fork, are to be found the long since abandoned Esslemen's mines. The coal is reported by the old settlers to have been impure, and for that reason abandoned. None of these ridges, near the river, are high enough to take in the solid capping of conglomerate, which begins, however, from this point to show itself towards the south and west. Passing the Little South fork, the next opening is called Dick's Bank. It lies in the nose between the Big South fork and Wild Dog creek, facing the former at an elevation of about 350 feet above low water. It is now abandoned; but, when worked, it is said to have produced a good coal, averaging forty-six inches. The floor for three feet is composed of a compact bluish shale, and the roof of a sandy shale, filled with carbonaceous matter, in the form of stems and leaves,

capped in its turn by the universally found stratum of hard gray sandstone. Above are about 100 feet of ferruginous shales, containing a thin vein of coal, the whole protected by massive cliffs of the conglomerate, which here form the ridge top. The McKee and lowest beds are reported to be here; but I could see no outcrop, though their terraces are strongly marked. This Dick's vein, as well as the Dodson vein, is described as pitching into the hill and then becoming level, a peculiarity strongly marked in the main coal bed of the Kentucky river.

The ridge containing the main vein which has been opened at Dick's bank claims particular attention, as it probably affords the best coal of any yet mined up the South fork, which is no doubt partly due to its excellent capping, and also because it is at the present head of navigation—the celebrated Dick's Jumps, just above the mouth of Wild Dog creek. These Jumps are formed of immense masses of the conglomerate which have fallen from the neighboring hills, and now lie in the river, blocking it up, and rendering navigation from above impossible. This is a serious obstacle to the prosperity of the neighborhood, as the coals could be worked much more cheaply further up, where the southeast dip has brought them down nearer to water level. A careful examination of the river, leads me to believe that a small expense would get rid of these masses of rock, lying, as they do, in very deep water, where a single heavy blast would cause many of them entirely to disappear beneath the surface.

Just above the mouth of Wild Dog creek, and, indeed, at many points on the river, excellent sand beaches occur, where boats could be built and turned, without much danger; and the limestone benches, which here line the river and its branches, could be cultivated and made to supply, not only the builders, but the miners, with all the necessary cattle and grain, the fine water power of the creeks being used to grind the latter, and the ridge land above affording excellent summer pasturage for cows and sheep.

West of the Jumps, and in the ridge dividing Turkey creek from Denney fork of Sinking, the main bed has been opened by Jackson Denney, 160 feet above the limestone, and forty-five inches thick, marked with seams of sulphuret of iron at the outcrop, but said to lose this blemish when pursued beneath the hill. Eighty feet above it runs the base line of the conglomerate cliffs, which are here 90 feet high.

Within 30 feet of the base of the cliffs lies a heavy band of shale, containing iron ore. At the usual distance below the main coal are the well defined terraces, which mark the lower coal veins. Here it is that the ripple-marked, fine-grained sandstone, overlying the lowest coal, shows itself in force, in successive layers of about eight inches thick, and quarrying in ten foot slabs, admirably adapted for building purposes.

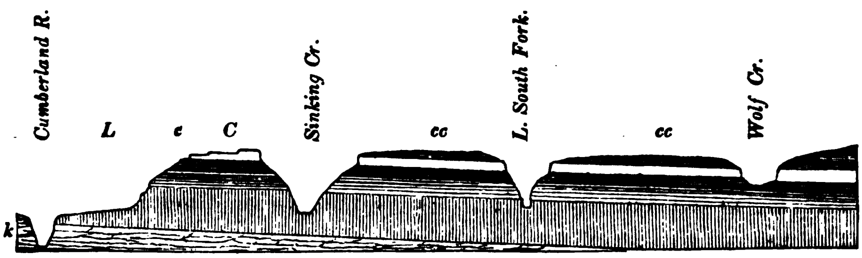
To the northwest of this, two coal banks occur in the long ridge lying between Middle and Big Sinking creeks, and the waters running north into the main river. The first of these is Sloan's, described in Vol. 1, p. 244, of the Reports; whilst the second has been recently opened by a Mr. Alexander, on that part of the ridge between the Dry fork and Elk Spring creek. The outcrop measures forty-two inches —the lower three inches slaty; its capping is a gray, shaly sand rock; and its elevation above tide 1,370 feet.

The hills around Monticello are not high enough to take in the main coal bed; but the lower one has been opened at various places in the vicinity, and is praised by the blacksmiths.

The main bed will, no doubt, be found extending over the whole of this county south of the Little South fork, and can be mined along nearly its whole length, as well as on the Big South fork as high up as Wolf creek, where it is said to cross the river and go under water level.

The iron ore belt lying above the McKee bed is strongly marked on the river in the vicinity of the three Sinking creeks; but, unfortunately, I was not able to remain a sufficient length of time in the neighborhood to get its thickness, though I believe it to be well worthy the attention of iron masters.

The conglomerate in this county, where measured, attained a thickness of 90 feet, and the lower member of the formation measured 240 feet. Wayne may be said to be based upon the sub-carboniferous limestone, in which nearly all the streams have cut their beds, the Cumberland river being the only one which runs in the underlying knobstone, whilst Rock creek is the only important one which cuts its whole length in the overlying millstone grit formation. The following section, from the S. E. corner of the county to Mill Springs, on the river, will explain this, and also show the general disposition of the rocks and their dip:



No county on our line is so favored by an equal distribution of farming and mineral land as this. Rich, broad, and gently sloping limestone vales run up between the narrow ridges containing the precious minerals; while to the northwest extends throughout the county, in a broad band, that fertile limestone table-land, paradoxically called "The Barrens;" and below this elevated terrace are the equally rich bottoms of the Cumberland river. "The Barrens" have a gently undulating surface, of the red calcareous soils of the *Lithostrotion* division of the sub-carboniferous limestone, and, at the period of the early settlement of this country, were nearly destitute of trees, being represented in the records of that day as having the appearance of open prairies covered with long, rank grass. But at present, where not under cultivation, they luxuriate beneath a heavy growth of timber, principally of black oak and black walnut, through which hickory, dogwood, and black gum are common. The surface, in many parts, is strewn with the yellow, cherty masses, so commonly met with in Kentucky at this geological horizon, embedded in a red clay soil, which, at some points, is, at least, twenty feet deep. A different kind, called "nigger heads," is found with them, and produces, when ground up, a manure, said to be particularly adapted to the soil upon which it is strewn. Between the wide rolling noses of the Barrens, are frequently to be met estuary-like bottoms, called "flat lands," "crawfish lands," &c. These extend over wide surfaces between Otter and Beaver creeks, and grow timothy and herd grass well, but trouble the farmer to get from them good crops of corn or grain. The timber is mostly white oak and pin oak, hickory, and sugar tree. Specimens of the soils of this county have been carefully collected for analysis.

The Barrens of this county are full of sink holes, caused by the

k. Knob formation. *L.* Sub-carboniferous limestone. *c.* Sub-conglomerate measures. *C.* Conglomerate. *cc.* Coal measures.

cavernous character of the underlying strata, spoiling the surface drainage of the country, and compelling the farmer to sink deep wells for his supply of water, unless he lives near the edges of the great plateau, in which case he will be abundantly supplied from the large springs which issue from the face of the cliffs, and which, if utilized, could perform much of the lighter labor of the farm. The streams which cut through the limestone in a northwest direction fall rapidly, and would furnish an abundance of power.

CLINTON COUNTY.

The coal area of this county is very small, and includes only the western half of the Poplar mountain, along with two outliers: the first on Short mountain, between Otter and Indian creeks; and the other, occupying the top of the ridge between Wade's and Caney gaps. The main coal bed of the Cumberland river seems to be the only one which has been worked in this county. At Dr. Long's bank, in the north point of Poplar mountain, it is 165 feet above the limestone, and 35 feet below the conglomerate, which latter caps the ridge at this point, and is 70 feet thick—the top being 445 feet above Wade's gap, or 1,678 feet above tide. There are terraces below this main bed which correspond to those of the lower coals on the South fork; but no outcrop signs were discovered in the Poplar mountain. Dr. Long's coal shows a thickness of four feet, and has a solid roofing of fossiliferous sandstone, which undulates along some of the drifts, at the expense of the thickness of the bed. These are called "horse-backs" by the miners, but bear only a distant resemblance to those properly so called, whether in metallic veins, or in more disturbed coal regions.

South from these banks, in a spur of the Poplar mountain, known as the Copperas knob, this same bed has been opened in several places by Lewis Huff. It lies 160 feet above the limestone, and presents the same peculiarities as at Long's, being 4 feet thick and containing sulphuret of iron nodules. It has been traced in the other spurs of the mountain, and is known to exist in the spur extending westward from Long's bank to the Caney gap, north of Albany.

I was prevented by sickness from examining the iron ores of this section as fully as I could have wished, though there seems to be but little hope of finding them sufficiently developed to warrant the erection of blast furnaces. In the Sinking country, to the south of Albany, my

attention was called to large areas covered with an apparently rich iron ore, some specimens upon the farm of George M. Denton having the usual brown hematite character, whilst others were honey-combed and very fossiliferous. No diggings having been made, it was impossible to arrive at the quantity of this ore, specimens of which have been submitted to the State Chemist for analysis.

The outcrop base line terminates in the southeastern corner of this county, at a point on the Alabama stock road, 1,996 feet south of John Crouch's house. A white oak, standing to the east of the roadway, and marked, "St. 9272 B. Line," shows its terminal station.

TOPOGRAPHICAL

GEOLOGICAL REPORT

OF THE

PROGRESS OF THE SURVEY OF KENTUCKY,

FOR THE YEARS 1858 AND 1859.

BY

SIDNEY S. LYON, Topographical Assistant.

INTRODUCTORY LETTER.

To Dr. D. D. Owen, *Principal Geologist:*

Sir: I herewith transmit my Report of the progress of the work of the Geological Survey of Kentucky, made by Corps No. 2, during the year 1858, according to your instructions, a copy of which is hereto annexed.

All of which is respectfully submitted.

SIDNEY S. LYON.

INSTRUCTIONS

FOR THE GUIDANCE OF S. S. LYON, TOPOGRAPHICAL ASSISTANT TO THE GEOLOGICAL SURVEY OF KENTUCKY, FOR THE YEAR 1858.

You will proceed, as soon as possible, to organize the base line party; and, as soon as the weather will permit, take up the line where it was left off last fall, and carry it through, in a due east course, to the Virginia line, with as much dispatch as is consistent with accuracy and permanency.

While on that line, wherever a favorable opportunity offers, you will make accurate and minute geological sections of the strata that present themselves on, or sufficiently adjacent to, the line—not to consume too much time in their construction, or interfere with the main object of the work. You will also make such collections, as opportunity may afford, of all remarkable or interesting soils—*i. e.*, such that can be either definitely referred to a particular geological formation for its derivation, or to individual members of any formation—or such as have interest from supporting any particular growth; or such as seem to be deficient in any particular ingredient, from failing to produce certain crops.

You will also make collection of such ores, minerals, rocks, or fossils, as may be of practical interest and importance.

So soon as the base line is completed, you will disband such members of the corps as may not be required in the prosecution of the topographical work, to be continued through the counties of the western coal field; and then, organize the western corps to proceed with the detailed Topographical Geological Survey of Hancock county, so as to enable you to construct a map of that county on the same scale and style as that of Hopkins county; and carry through said county of Hancock such a system of levels, as will enable you to lay down and report on the relative elevations of the various outcrops of coal, limestone, ore beds, or such beds of rocks as will enable you to identify the horizon of the leading and important members of the western coal measures.

When the Survey of Hancock county is completed, you will proceed with the detailed Topographical Geological Survey of Grayson county, on the same plan as that of Hancock.

During the month of October, you will take a few weeks to make some special collections, at localities of peculiar interest in the various departments and branches of the Survey.

In the latter part of the season, when the weather becomes unfavorable for field operations, you will, with the aid of your sub-assistant, plat up the work of the season, and construct the maps of the counties surveyed, to be ready as early as possible for the engraver.

D. D. OWEN, *State Geologist.*

CHAPTER I.

The necessary preparations having been made, the base line party arrived on the ground and began their labors on the 26th day of April.

The monuments set up at the terminus of the line at the close of the last season were found undisturbed. No difficulties were encountered not necessarily connected with a work of this character, other than those incident to the organization of a party composed of persons not previously engaged in such work. All parties engaging with a good will, the zeal of those employed soon enabled each to perform his duty, and the work made fair progress.

During the early part of the season the work was much retarded by frequent and continued rains.

In addition to the observations made on that part of the line previously run—reaching from Uniontown, eastwardly, 376,847 feet, or 71¼ miles—observations were frequently taken by the barometer to determine the elevations of important points along the base line.

The party were kept at work until the 18th day of September, when the field work on the base line was closed for the season, on the waters of Jenney's creek, near the Big Sandy river.

The total length of the line up to this point was 1,468,757 feet, or 278 miles 917 feet. The distance accomplished this season being 1,091,910 feet, or 206 miles 8 poles.

The season being far advanced, our outfit being insufficient for the residue of the line, the members of the corps being worn out by the length of the time employed, and the mountainous character of the country beyond rendering a different organization of the corps necessary, it was deemed advisable to disband the base line party for this season, especially as one of the wagons and team employed by the base line party was required for the use of corps No. 3 in the operations in the eastern coal field. As soon as the other team was recruited and preparation could be made, I proceeded to make a reconnoissance, preparatory to the work of next season, around the eastern margin of the coal field lying in Grayson, Edmonson, and Hart counties, which was farther extended

into Warren, Allen, Larue, Hardin, Nelson, and Bullitt counties, making at the same time the collections as specified in the instructions.

The topographical and geological details of the country crossed by the base line will be seen by the accompanying diagram and section. The length of the line run can only be conveniently exhibited on a very reduced scale, viz: of six miles to the inch.

It will be seen by the diagram referred to that the line begins at Uniontown—which is situated in a nearly level country, though, geologically, the rocks lie high in the coal measures of the west—and that it crosses successively the coal measures, the millstone grit, and the intercalated beds of limestone associated with it, the sub-carboniferous beds of limestone, and the sandy mudstones of the beds usually called the knobstone.

Descending the sub-carboniferous beds near the valley of Salt river, the line runs on the low valley of the Beech fork of Salt river, on the beds of black slate, the next rock in the descending series, occasionally crossing spurs of the knobstone.

The black slate in the vicinity of the line rests on beds of the Upper Silurian rocks of the age of the Niagara group of the New York State Survey. Hills of inconsiderable altitude frequently including the knobstone, black slate, and considerable masses of the Silurian rocks at the base. As the country becomes higher, toward the east, the black slate forms outliers, capping the hills in the eastern part of Nelson and the western part of Washington county. The shaly limestone beds are cut by the valleys in Nelson county, and form no inconsiderable portion of the surface rock of the western part of Washington county.

After leaving the valley of Cartright's creek, for a short distance the sandy mudstones of the Silurian period occupy the surface. These beds frequently alternate with a soft friable shell limestone.

All the beds are generally soft, and easily cut by running water, thus producing a rolling country—locally quite fertile. One mile west of the last crossing of Salt river, the base of the sandy or muddy silicious beds come to the surface. From Salt river to the valley of Dick's river the country is elevated, nearly level; and the general surface rock is the cavernous bed of the Lower Silurian period. This bed gradually changes by intercalation of the upper and thin plate-like layers of the bird's-eye limestone. This last rock forms the walls of the gorge in which Dick's river flows. Occasional patches of the sandy member are

seen on the west side of Garrard county. The base line crosses Kentucky river near the mouth of Big Hickman creek. The base of the sandy mud beds were not seen at the crossing into Jessamine county. A fault which is coincident with the valley of Hickman creek has carried this rock on the east side of the creek below the surface of the Kentucky river, where the line crosses it. The sandy mud beds are gradually ascended, and are found covered by the yellow magnesian beds of the Upper Silurian group at the crossing of the Lexington and Richmond turnpike, near Richmond. About four miles east of Richmond the black slate, which was last seen in Nelson county, is again the surface rock, rising even in elevated positions; the streams cutting into the yellow beds beneath. This alternation continues to the last crossing of the Kentucky river into Estill county. The last portion of the line cutting the Silurian rocks is at White Oak creek, on the east side of the Lone knob.

The land now suddenly assumes an elevation above the valleys of about 600 feet, and contains, in sections, sandstones of the millstone grit (?), or coal measures, on the top of which rest the whole body of sub-carboniferous limestone, the black slate, and a few feet of the Silurian rocks at the base, including the horizons of the beds of iron ore of Bullitt and Nelson, as well as the beds, probably, equivalent to those of Lyon and Marshall counties, on the western margin of the western coal fields.

Here, in a space of 600 feet, we have rock formations which, in the west, occupy probably 2,700 feet in thickness. The base line from the last crossing of the Kentucky river became very laborious, the country being traversed by deep rocky valleys, from 400 to 500 feet deep, the walls generally vertical, the width varying from 300 to 1,600 feet, while the country is generally heavily timbered and grown up with an undergrowth of hickory, oak, red bud, black locust, &c., depending upon the geological member forming the surface rock—the great feature of the country and of the geology being the great sandstone, so well seen at the old furnace, and known as the State House.

From the vicinity of the old furnace to the crossing of Swift's Camp creek, this notable sandstone is seen in every valley crossed by the line. After crossing Swift's Camp creek, softer beds of the coal measures form the surface rocks, and continue until the line reaches the ridge at the head of Red river, which divides the waters of the Burning fork of

Licking from the head waters of Jenney's creek. The heavy sandstone formation of these ridges is probably the geological equivalent of the sandstone at the top of the section, near Mount Savage furnace, and is considered to be the highest member observed in the coal measures of this region. Since the beds are frequently very much modified in a short distance, minute geological sections were incompatible with the objects of the base line survey; and, indeed, are only of local interest.

To the foregoing statement of the general features of the country traversed by the base line, I shall add a few details and local sections, taken at different points along the line, with some inferences, along with some other observations made in connection with my field work in other parts of the State during the last five years.

The value of the observations made by myself and other members of my corps, is much increased by their continuity, without breaks, over extended tracts of the country; and further, having no special theory to support, I have only followed, or endeavored to follow, the deductions necessarily flowing from the facts themselves.

SPECIAL GEOLOGY OF THE BASE LINE IN BRECKINRIDGE COUNTY.

The following section, taken near the base line, opposite 378,337 feet post, will serve to show the stratigraphical arrangement of the upper beds of the millstone grit, on the eastern edge of the western coal basin.

No. 1. *Section of King's hill, Breckinridge county, east side of Fur fork of Clover creek, the top of the hill being capped with loose blocks of sandstone, which was traced to the yellow sandstone under the "Breckinridge coal," Hancock county, one and a half miles distant:*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Blocks of coarse sandstone, marked by bands of ferruginous stains	21	8	344	8
Thin bedded sandstone	63	------	323	------
Earthy limestone, on surface	5	4	260	------
Steep, covered space, limestone, (?)	10	8	254	------
Slope, covered space, aluminous shales, (?)	84	------	244	------
Beds of limestone, containing Productus and Crinoidea	30	------	160	------
Limestone, containing great numbers of Belerophon	37	------	134	------
Covered space, showing occasionally beds of aluminous shale; base of the mass of black shale	53	4	97	------
Limestone in place, thick beds	13	8	44	8
Aluminous shale	11	------	31	------
Thin bedded sandstone	10	------	20	------
Ledge of sandstone, "Tar Rock"	10	------	10	------
Top of limestone.				

To this may be added the following section, taken immediately north of this locality, and at the Tar Spring. The sections united will form a continuous section. The lower sandstone in section No. 1 is the equivalent of the sandstone at the top of the following section, and is here the place of the tar deposit, which flows down through fissures in the inferior beds, and at the Tar Spring flows out at the base of the sandstone first below this bed:

No. 2. *Section at Tar Springs, Breckinridge county.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Tar sandstone, thin beds	16	------	190	2
Tar sandstone, thick beds	14	8	174	2
Yellowish-gray thin bedded limestone, containing Retepora, Archemides, Pentremites, &c.	32	4	159	6
Whitish limestone, thick beds	5	------	127	2
Mass of coarse sandstone	20	------	122	2
Four masses of sandstone beds, well defined by the obliquity of the deposition of the different beds	62	2	102	2
Marly shale, containing lenticular masses of limestone	3	------	40	------
Limestone	1	6	37	------
Blue-gray marl	------	6	35	6
Covered space, probably limestone	35	------	35	------

The Tar Spring sandstone is cut by Clover creek, at the crossing of that creek by the line.

In the foregoing sections a thickness of 534 feet 10 inches of the sand and limestones of the millstone grit beds are given, which circumscribe the coal field of the west on this part of its margin.

Before proceeding eastward, a few remarks will be made in reference to the beds lying above the top of the masses in section No. 1.

The section given in Vol. 1, Kentucky Geological Reports, diagram No. 4, gives the equivalent of the rocks both above and below sections Nos. 1 and 2 united.

On pages 458 and 459, Vol. 3, Kentucky Geological Reports, a section of the masses near the margin of the coal field is given. On the line westward from the Tar fork of Clover creek to Knottsville, the measures are undulating, and frequently cut by the head branches of Blackford's creek.

It is probable that there are no coal beds of workable thickness on the line east of the Hawesville and Hartford road, in Hancock county.

The country between Knottsville and Yellow creek exposes only the beds of the Hawesville section, and those of the section given on pages 458, 459, and 461, Vol. 3, Kentucky Geological Reports.

The beds associated with the Estis or Lewisport coal, were not recognized on the line east of Yellow creek. The line running along the crest of an anticlinal wave, it is probable the beds last alluded to are wasted by denudation in the vicinity of the line, east of Yellow creek; and that they are carried down by rapid dip near the creek, and are lost under the soft beds west of it.

West of Yellow creek the country is covered by the silicious quarternary marls, and no section could be obtained between the creek and Green river.

West of Green river the upper part of the coal measures, associated with the coal beds worked at Newburg and Evansville, Indiana, come to the surface. The section of the Holloway borings, in Henderson county, given on pages 32 to 36, Vol. 1, Kentucky Geological Reports, will serve to illustrate the geology of the line from Green river to Uniontown—it need not be repeated here.

Returning toward the east we find the great sandstone of the Tar Spring forming the banks of Clover creek; the masses covering the sandstone having suffered considerable alteration. The limestone immediately above is semi-oolitic; the upper part of the mass being buff colored, and abounding in *Pentremites*, *Phyriformis*, and *Retepora Archemides*. At the crossing of the Beech fork of Clover creek the great sandstone is beneath the drainage, and is not cut by that creek where we crossed it. The section at Beech fork is identical with the following, taken at Clover creek, except the lime and sandstone masses at the base:

No. 3. *Section of the millstone grit bed at the crossing of Clover creek.*

	Feet.	Inches.	Total.
Covered space	41	------	158
Buff Pentremital limestone	12	------	117
Oolitic limestone, (fossils rare)	12	------	105
Sandstone, single ledge	14	------	93
Heavy bedded sandstones, oblique lines of deposition	45	------	79
Talus	20	------	34
Dark gray concretionary limestone	14	------	14
Bottom not seen. Bed of creek.			

The creek, where the line crosses it, evidently lies in a synclinal fold, with a rapid dip toward the northwest.

Between Clover and Sugar Camp or Doverty's creek the line lies upon an elevated plateau, with no large streams crossing it. The upper part of section No. 3 is cut at Mr. Weatherford's, on the Hardinsburg and Hartford road, a short distance south of Hardinsburg.

At Sugar Camp creek the following section is visible:

No. 4. *Section at Sugar Camp creek.*

	Thickness.		Elevation.	
	Feet	Inches	Feet.	Inches.
Covered space over limestone—generally flat knolls	25	......	150	5
Limestone, Pentremites, &c.	24	......	125	5
Covered space, wasted sandy shales	32	......	101	5
Buff limestone beds	5	4	69	5
Oolitic limestone, fossiliferous	5	4	64	1
Oolitic limestone, few broken fossils	5	6	58	9
Whitish beds, limestone Pentremites abundant	5	4	53	3
Hard bluish limestone	5	3	47	11
Six plates of limestone, the lower three full of segregations of chert	5	4	42	8
Limestone with regular beds of chert—fossils rare	6	......	37	4
Covered space, waste of limestone	10	......	31	4
Fine grained yellow sandstone	5	4	21	4
Bed of sandstone	16	......	16	......
Bed of creek, top of Tar Spring sandstone.				

After leaving Clover and Sugar Camp creeks the line lies on the south side of the dividing ridge, between the waters of the streams emptying into the Ohio river and those emptying into Rough creek. The head of some of the streams emptying into Rough creek are cut on the 85th and 86th miles. Near the 86th mile post the drainage cuts through the Tar Spring sandstone, the bed of limestone beneath it, and into the lowest and last sandstone of the millstone grit.

The following section, taken near the 86th mile post, corresponds very nearly with a section obtained one mile west and two miles south, at Mr. Compton's, on Lost run. Immediately west of the place of this section the sandstone of the Tar Spring rises in a bold precipice, where this rock is seen forming a bluff for the last time along the line:

No. 4. *Section on the farm of the Widow Whiteworth.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Rounded outlier of the Tar Spring sandstone, showing 35 to 40 feet sandstone at the base	50	------	151	4
Aluminous and micaceous sandy shale	10	8	101	4
Hard crystalline limestone, thin beds	5	------	90	8
Hard crystalline limestone, containing great numbers of Belerophon	2	6	85	8
Earthy limestone, dingy-buff color, containing few or no fossils	14	6	83	2
Limestone, abounding in Pentremites and Crinoidea, with a few Terebratulæ	4	------	68	8
Limestone, whitish colored, fossils rare	10	------	64	8
Covered space, showing occasionally beds of blue aluminous shales	12	8	54	8
Covered space	16	------	42	------
Thin bedded sandstone	26	------	26	------
Bed of branch, on sandstone.				

Eastwardly from the place of this section, the sandstone at the base of the millstone grit to the valley of Sinking are frequently cut through, and the upper beds of the great mass of the sub-carboniferous limestone exposed. The base of the foregoing section, (No. 4,) was obtained on the 87th mile, as follows:

No. 5. *Section near the farm of Mr. Perin's.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandstone, equivalent to sandstone at 26 feet of section 4	25	------	99	------
Sandy and aluminous shale	10	------	74	------
Limestone, descending into the cavernous member of the sub-carboniferous limestone	64	------	64	------

Half a mile east of Mr. Perin's, on the farm of Mr. Chandoin, the limestone at 68 feet, section 4, is the surface rock. Near the line, the sandstone at 99 feet, section 5, appears impregnated with desiccated coal tar, and persons have made an effort to trace the tar to the coal bed from which it is supposed it flowed. There is locally a thin bituminous shale at the base of the sandstone, from 4 to 6 inches thick. The section at Mr. Dent's, two miles east of Mr. Chandoin's, and one and a half miles north, is the counterpart of that at the latter locality.

It would be proper to state that, at the locality of section No. 5, part

of the wasted mass of the Tar Springs sandstone is in sight, forming an outlier of that mass, reduced to a few acres in extent.

No. 6. *Section at Mr. Dent's, west side of Sinking creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Tar Springs sandstone	14	6	97	2
Limestone	34	------	82	8
Shale and clay bed	8	------	48	8
Sandstone	3	------	48	------
Limestone	1	------	45	------
Sandstone	4	------	44	------
Sub-carboniferous limestone, (?)	41	------	40	------
Drainage, dry ravine.				

Sandstone No. 3, or the Tar sandstone of Breckinridge county, forms the surface rock at Mr. Chandoin's, on the 88th mile. On the 89th mile the drains emptying into sinkholes, and those emptying into Sinking creek, cut through the beds lying above the cavernous member of the sub-carboniferous limestone, and down to that member. The dividing ridge between the waters of Sinking and Rough creeks are capped by the lowest sandstone, limestone No. 1, and, on the higher parts of the ridge, by the waste of sandstone No. 2, or the sandstone forming the great bed at the Tar Springs.

The dip observed at various points in the vicinity of the head of Sinking creek indicates a dome-like upheaval, somewhat prolonged in the direction of Big Spring; the apparent longer axis of this upheaval from east to west being about eight miles—that from north to south about two miles. The territory included within this limit being entirely surrounded by a band of the sandstone beds Nos. 1 and 2, with the included bed of limestone No. 1. Toward the north, in the direction of the mouth of Sinking creek, the dip brings sandstone No. 1 down to the level of the drainage. Still further north the beds of sandstone Nos. 1 and 2 are raised again, and at the Ohio occupy a position from 100 to 150 feet above the river.

The sinks and basins at the head of Sinking creek exhibit, in a striking manner, the eroding effect of rains and frost — some of the sinks, which are from forty to one hundred and ninety feet deep, covering an area of from five acres to two thousand. The rim of sand-

stone surrounding these depressions is, generally, nearly level; the outcropping rocks within are also nearly horizontal. Near the center there is an opening of from three to fifteen feet in diameter; into this opening the water which has fallen within the margin of the basin has been drained since the day when the rocks exposed within were raised above the drainage of the country, and thus, by the slow process of washing and weathering, the rocks, which once filled these cavities, have been worn and carried down into the subterranean drainage of the country. All this has evidently come to pass in the most quiet and regular manner. The size of the central opening is too small to admit extraordinary floods; nor is it possible, with the level margin around, to suppose that these cavities were worn by eddies in a current that swept the whole cavernous member of the sub-carboniferous limestone of western Kentucky; but the opinion is probable that the upheaving force which raised these beds to their present level, at the same time ruptured and cracked the beds in certain lines; that afterwards the rains were swallowed into openings on these fractures, producing, by denudation, the basins of the sinkhole country, and further enlarging the original fractures by flowing through them, and thus forming a vast system of caverns, which surrounds the western coal field. The Mammoth Cave is, at present, the best known, and, therefore, the most remarkable.

The following section, taken three fourths of a mile north of Mr. Felix Styles', (94th mile,) will carry the sections into the sub-carboniferous limestone, and connect that member with the sandstone and limestone beds above it:

No. 7.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, wasted sandstone	15	6	214	4
Fine grained sandstone	5	6	198	8
Fine grained sandstone, containing round segregations of pyritiferous sandstone	5	------	193	2
Coarse sandstone, containing balls of sandstone	5	------	188	2
Heavy sandstone, ripple marked, with oblique marks of deposition	10	------	183	2
Thin bedded sandstone	26	------	173	2
Covered space, shales, (?)	5	4	147	2
Oolitic limestones	5	4	141	8
Bluish-earthy limestone, with silicious segregations	5	------	136	4
Earthy and oolitic limestone, with remains of Crinoidea near top	21	8	131	4
Ledge of compact limestone	10	8	119	6
Ledge of whitish limestone, earthy near the top	10	8	108	8
Chert bed	1	6	98	------
White limestone, containing Crinoidea, *Dichocrinus beds*	21	------	96	4
White limestone, with Crinoidea	10	8	75	4
White and blue beds limestone, alternating	16	------	64	6
Blue beds of limestone	21	6	48	6
Buff silicious limestone	5	4	------	------
Hard blue-gray limestone, with Productus	5	------	21	6
Hard gray limestone, with Crinoidea	5	8	16	6
Hard gray limestone, with Pentremites	10	8	10	[illegible]
Flat at Sinking fork of Sinking creek.				

About ten feet below the base of the sandstone, the bedding places of the limestone are completely covered with the remains of Pentremites floralis, P. pyriformis, and P. globosus.

The rocks are quite hard, and the fossils crystallized carbonate of lime; they are not disintegrated, but weather as fast as the rock in which they are imbedded. About fifty feet from the base of the sandstone the red earth first appears. This is the usual color of the subsoils of the sub-carboniferous rocks below the sandstone. The action of the rains on masses of this rock is remarkable. Rocks which are detached, and stand isolated and unprotected, are weathered into deep fluted furrows by the falling rains, while the extreme upper parts of the ridges between the furrows are kept quite sharp. The same beds have since been seen in the Mammoth Cave, which are readily recognized by the same flute-like grooves produced by water trickling over their exposed faces. This is the more remarkable when the texture of the rock is considered. It is quite fine grained, and compact.

The base line, after it crosses Sinking creek, soon ascends a platform of sandstone, lying quite level, and seldom penetrated by the water.

Here we have surface drainage on the north into the sinks and Sinking fork of Sinking creek, and on the south side into the sinks and Rough creek.

This table land extends to the head of May's creek, a tributary of Rough creek. Further eastward, the sandstones between the conglomerate and the cavernous member of the sub-carboniferous limestone are only seen in isolated patches on the knobs, which stand here and there detached from the main mass of sandstone, which caps their summits, and, from its resisting character, maintains these knolls in their present form.

From May's creek to the head of Otter creek, the rocks are nearly level, with a slight dip to the west and southwest. From the one hundredth mile to the crossing of Otter creek, the sinks are less numerous, the valley of Otter cutting below the cavernous member, the hills on the east and west sides being capped with it. The drains usually lie on the surface, with occasional large springs breaking into the valleys. A short distance from the eastern edge of the sandstone the chert waste from the sub-carboniferous rocks covers the surface, and is more or less abundant from the 100th to the 115th mile; for this distance the chert is quite fossiliferous, and usually cellular.

No satisfactory section of the whole mass of the cavernous member could be obtained along the line; it is estimated at about four hundred feet. The rocks at the base of it are earthy, and frequently contain beds of marly clay. The upper part being generally hard and brittle, containing two distinct beds of oolitic limestone.

On the 115th mile the line enters the breaks of Muldrough's hill, passing over the crystalline limestone beneath the clay beds, and cuts the head of Otter creek.

The line crosses the Louisville and Nashville railroad on the 116th mile, and enters the valley of Clear creek, descending the beds of the knob member of the sub-carboniferous rocks, which are here represented by alternating beds of limestone, chert, and silicious mudstone. Toward the base of the mud beds are a few layers of fine grained sandstone. These last beds are the equivalent of the Waverly sandstone of Ohio, and correspond to the geological horizon of the section taken at the mouth of the Scioto river, and reported on page 371, Vol. 2, Kentucky Reports. Some of the beds of limestones at the top of the mudstones

and muddy shale, on Clear creek, abound in Crinoidea, usually silicified and distorted; some of these remains are probably new, both in genera and species.

The valley of Clear creek, but especially the cut made by the Louisville and Nashville railroad company, afford fine sections. The line of the road ascending the hill, the entire section of the hill may be obtained. Here, as has been frequently observed elsewhere, the rocks are interrupted by numerous waves, and the dip falls off with the line of the creek, which would reduce the thickness of the rocks to less than the height of the hill. No good section of the base of the knob member was obtained on the west side of Rolling fork of Salt river, which the line crosses near the mouth of Beech fork, on the 120th mile.

The black slate, usually considered of the Devonian period, is first seen on the base line at the crossing of Rolling fork.

The level land on Beech fork to the 126th mile lies on the black slate. At this point the drains and branches begin to cut through the slate, and expose, occasionally, the beds beneath it The shales and sandy mudstones at the base of the sub-carboniferous beds form the hills and ridges. Outliers of the black slate are seen occasionally up to the 134th mile, beyond which it is no longer seen.

The dip to the west, from the 134th mile westward to Rolling fork, is quite gentle and regular.

No. 8. *The following section, taken at Mr. Jonathan Newman's, on Long run, will serve as a key to the arrangement of the rocky masses of the hills:*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of remains of sandy mudstone.				
Waste of knobstone	47	......	146	5
Aluminous shale	19	......	98	5
Hard fine grained sandstone	......	3	79	5
Waste of black slate	14	......	79	2
Black slate, stained with oxide of iron	27	6	65	2
Black slate	22	......	38	6
Yellowish and flesh colored limestone, upper surface water worn, containing remains of encrinites, corals, &c.*	......	......	......	......
Limestone, buff colored, containing *Cariocrinus ornatus*, *Pentamarus oblongus*, &c., equivalent of the Niagara group	11	......	11	......
Bed of Long run.				

* This bed of 5½ feet, under the black slate, and above the Silurian beds, containing imper-

The hills gradually increase in height as the line passes up the river.

The black slate has decreased in thickness from the Ohio river. On Long run it is found only 63 feet thick, while at the Ohio it is upwards of a hundred feet.

The limestone at 16 feet, 6, is frequently wanting on the line: the slate there resting on the Silurian beds.

The Devonian limestones, which are estimated at from 20 to 30 feet at the falls of the Ohio, have entirely disappeared, having thinned out toward the south, or been removed by denudation before the deposition of the black slate.

The beds being thus contracted, hills of inconsiderable height are found containing all the remains of the black slate, the Devonian limestone (?), and a part of the Silurian rocks; the whole capped by the mudstones of the lower part of the beds of the knobstone.

The general direction of Beech fork is from east to west from the 121st to the 141st mile, near Fredericksburg, when the direction is from north to south. The base line crosses this river twice on the 121st mile; the 131st mile post falls in it. It is crossed again at the 134th mile and the 136th mile; both posts falling in the river. It is again crossed twice on the 139th mile; and the last and eighth time at the mouth of Cartright creek. At this point the line enters Washington county. The shaly shell beds of the Silurian date are cut through, and the upper beds of the silicious mudstone are first seen on the slopes of the hill west of the last crossing.

The following sections, taken at different points from the crossing of Rolling fork of Salt river to the last crossing of Beech fork, will show the arrangement of some of the beds, and the modifications and changes exhibited in short distances:

No. 9. *Section on 126th mile.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, waste of knobstone	20	------	90	------
Knobstone in ledges	40	------	70	------
Knob shales, (silicious mudstone)	30	------	30	------
Top of black slate.				

fectly preserved Crinoidea, which appear to be allied to sub-carboniferous forms. Should future researches determine these fossils to be analogous to the sub-carboniferous, and not to the Devonian types, it would be necessary to separate the black slate from the Devonian, and place it at the base of the sub-carboniferous beds.

The 30 feet shale bed is much thicker farther west; and the ledges of knobstone are seen here for the first time on this line. These rocks appear to be solid, and of good quality; they may be wrought, and would, probably, produce a building material equal to the Waverly sandstone.

No. 10. *Section on 127th mile.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Base of black slate?				
Yellow Crinoidal limestone	3	------	80	------
Soft earthy limestone	5	------	77	------
Rough weathering buff limestone	15	------	72	------
Thin bedded limestone	14	------	57	------
Soft earthy limestone, whitish	10	------	43	-----
Harder beds limestone	15	------	33	------
Marly (?) clay shale	10	------	18	------
Clay, white	8	------	8	------
Bed of branch.				

The soils produced by the disintegration of these beds is of excellent quality. From 20 to 40 feet of the upper part produces cedar, on southern aspects; below the cedar line, buckeye, beech, and hickory; on the lower part, about 40 feet, is mixed poplar, ash, sugar-tree, and beech, with occasionally walnut.

No. 10. *Section on 131st mile.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of hill	-----	------	21	------
Covered space, black slate	54	------	-----	------
Yellowish limestone	14	------	156	------
Thin beds limestone, alternating with thin beds of marlite, with plates of soft limestone	15	------	142	------
Limestone, solid bed	18	------	127	------
Marlite, with occasional plates of limestone	26	------	109	------
Limestone, solid bed	14	------	83	------
Marlite, with plates of limestone	20	------	69	------
Bench and covered space	15	------	49	------
Limestone, solid bed	10	------	34	------
Marlite, with beds of limestone 8 to 10 inches thick	24	------	24	------
Bed of Beech fork.				

The 131st mile post falls in Beech fork; also the 134th. Between the two crossings of the river the land is spread out into a table, with

occasional rocky drains. The land is of excellent quality, produced by the disintegration of the shale beds at the base of the knobs, the black slate with the beds near the upper part of the Silurian limestone. Its color is dark reddish brown.

No. 11. *Section at the crossing of Beech fork, east of St. Thomas' College, Nelson county.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Black slate, capping river hills on northeast side of river	18	......	21	8
Top of second cliff	49	......	20	8
Top of first cliff, composed of two members	32	6	141	8
Foot of cliff, covered space	75	10	119	2
Foot of steep bank, covered space	43	4	143	4
Water, Beech fork.				

Between the 134th and 135th mile posts beds of limestone are seen, equivalent to the Crinoidal beds of Guthrie's quarry on Beargrass creek, Jefferson county, Kentucky. In the wasted materials upon the surface the fossils of the sub-carboniferous beds—seen in Muldrough's hill, 300 feet above the black slate—were in great abundance. The fossils were cherty, and almost indestructible by the weather. Considerable beds of sub-carboniferous chert was also found. This place is notable as the most eastward limit of the remains of sub-carboniferous beds; and also for the appearance of the beds associated with the hydraulic limestone of the falls of the Ohio. The Catenipora and coral beds, equivalent to those at the falls of Ohio, are absent, and the Crinoidal beds rest on Silurian rocks, containing Pentamerus and Eucaliptocrinus.

The line on the 136th, 7th, 8th, and part of the 139th miles, lies on the north side of the river. On the 139th mile the river is crossed twice.

The rocks of section No. 10 are cut as they rise more rapidly than the river; the cuts are becoming gradually deeper into the beds.

No. 12. *The following section shows the modification of the beds eastwardly. The section does not reach to the horizon of the black slate. The distance from the top of section to the slate is only a few feet:*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Yellow limestone, 5 feet below slate, (?) and covered space	16	3	186	8
Red subsoil, lower part yellow marlite	32	6	170	5
Yellow marlite, a few beds of yellow rock on top	27	5	137	9
Covered space, covered with cedar	27	5	110	4
Yellow limestone, covered with cedar on all patches of soil	28	------	83	4
Yellow limestone	5	------	55	4
Thin bedded limestone, lower limit of cedar	10	8	50	4
Indurated blue silicious mud	5	4	39	6
Yellow drab marlite	16	2	34	2
Top of beds, containing spherical masses of Favosites.				
Fossil bed	10	------	18	------
Thin bedded gray limestone	8	------	8	------
Bed of Mill creek.				

Between the place of this section and Bardstown the decomposed layers of the argillaceous beds have been wrought into common earthenware, but the manufactory has been discontinued. The reason of its discontinuance I did not learn. The clay seems of good quality; though it may be wanting in silicious earth.

As before stated, the yellow limestone terminates on the line on the 140th mile, where the base of it caps the hills. The dip increases and brings up about 100 feet of the shell limestone; in the 139th and 140th miles are also a few feet of the silicious mudstone of the Silurian period, which is cut by the turnpike descending the hill from Bardstown, near Fredericksburg.

The belt of the soil which is characterized by the cliff beds of the Upper Silurian, extends along the line from the 124th to the middle of the 140th mile, 16½ miles. This belt is probably above the average width.

The belt of country particularly marked by the shell beds, silicious mudstones, and marl beds, extends from the middle of the 140th mile to the middle of the 166th mile, or 26 miles. As these beds are variously modified, being layers, alternately, of sandy mudstone, indurated aluminous shales, thin beds of shell limestone, or hard, resisting limestone. The outcropping edges of these beds produce, by disintegra-

tion, soils differing widely in chemical constitution, which consequently differ greatly in fertility: the character of the soil always corresponding in chemical elements to the beds from which it is derived.

On the silico-calcareous belt some of the beds coming to the surface are mostly composed of fine sand and silicious mud; when these cap a ridge, and no calcareous bed lies above them, the soil is quite poor, and the timber invariably oak. The same rock composing these oak ridges, when properly mixed with the waste of the calcareous or marl beds, produces a fertile soil easily cultivated.

The first characteristic bed of the silico-calcareous rocks of this part of the base line extends from the west side of Beech fork, from the 140th mile to Little Beech fork, on the 148th mile. This bed is composed of sandy mud shales and friable, irregularly thin bedded limestone, abounding in fossil shells. The most abundant of which are *Orthis*, and Spirifers, some of the beds being almost entirely made up of the latter genus. These beds are sometimes sufficiently solid to project in cliffs, but usually they are soft; and the country underlaid by these beds is in rounded hills and terraces; the soil almost invariably of a black or dark brown color. The last beds outcrop along the valley of Cartright's creek, and extend to the 147th mile. The beds coming to the surface here are more largely interstratified with beds of marlite. The hills are more rounded, and the soil is not so dark, partaking more of the yellow and whitish color.

The bold springs which mark the more open upper part of these beds in the valley of Cartright's creek, have no equivalent at the base of this sub-division of the Silurian rocks, where, the beds being quite close textured, the springs are generally feeble.

No good section was obtained of the beds coming to the surface, from Beech fork to Little Beech—no doubt on account of the softness and easily disintegrating character of the beds; there being in this region some 200 feet, beginning with the upper silicious mudstones at the top and ending with the lower sandy mudstones and sandstones, the edges of which are mostly concealed by debris.

The line of Doe creek shows a rapid dip from one to three degrees. From the 144th to the 146th mile the rocks dip nearly due west. This great dip brings up, on the east side of Little Beech fork, beds alternately sandy and calcareous, interstratified with marlite. These

beds are distinguished by a rolling country; the hills high; drainage cuts deep; and especially marked on the line by a growth of large poplar timber. These strata cover a belt of territory 10 miles wide, from Little Beech to the head of Glen's creek, from 148th to 158th mile. These beds are estimated at 250 feet of limestone and marl in the upper part, with 490 feet of sandy and muddy members at the base: making the whole mass 740 feet in thickness.

The western margin of this zone is somewhat modified by the waste of the beds spoken of as forming the west side of Little Beech fork.

The beds become more silicious on the east slopes.

At the head of Glen's creek is an oak ridge, covered in some parts by thin, fine-grained sandstones, which have resisted atmospheric action; while the softer, and more easily wasted beds, have crumbled and been carried away.

Eastward of the divide between Glen's creek and the waters of Chaplin fork 190 feet of beds are exposed, immediately under the sandstones of the divide before alluded to.

The zone covered by the outcropping edges of these and similar inferior beds crop out east of Chaplin, producing a country of similar soil and timber, extending from the first quarter of the 159th to the 164th mile, the surface gradually becoming more level toward the east. These last beds are composed of marlites, and soft shales, and fossiliferous limestone. The land is of superior quality; the hills rounded and short. This zone is particularly distinguished by the red oak timber, mixed with beech, poplar, sugar-tree, hackleberry, &c.—red oak being the most abundant. These beds extend from Chaplin to the dividing ridge west of Salt river, including the sandy beds at the base of this division; and are estimated to be 310 feet in thickness, from 10 to 15 feet at the base; being alternations of sandstone and marl in thin beds. The sandstone at the base is distinguished by producing, on ridges, *white oak* land. The white oak ridges of Mercer county are all derived from the wasted materials of this bed.

The limestone beds seen at the crossing of Salt river are cut in a few places by the branches west of the dividing ridge. The dip is so slight that it is only apparent by levels taken two or three miles apart. These comparatively horizontal rocks extend from 165th to 175th mile. The slight westward dip brings, however, west of Harrodsburg, about 240

feet of limestone to the surface, from beneath the sandstones of the oak ridges. It is the middle and lower part of this 240 feet of rock which produces the famous blue grass soils of central Kentucky. The masses of these beds are usually thin; the bedding surface generally uneven. The body of the beds being filled with the remains of fossil corals and shells. The action of the air, frost, and water upon these rocks is quite rapid, especially in immediate contact with the soil, and where it is not exposed to the direct rays of the sun. The rapid decomposition of these beds have supplied the waste occasioned by unscientific farming in the early settlement of the country. Some places have, however, been entirely denuded of soil, making unsightly spots in this truly beautiful district. The soil may be restored to such spots, if lying on a gentle slope, in a few years, by covering the bare rocks with waste straw, the halm of hemp, in fact, anything to prevent washing, and which will, at the same time, cover the rocks. A thin soil formed of the wasted mass of the rock, united with the covering material, will give sustenance to blue grass, which soon covers and accelerates the decomposition of the rock on which it grows and to which its roots cling.

Near the base of this mass of 240 feet are intercalated several beds of chert, seldom regular in thickness, and frequently interrupted. Immediately below the chert beds are to be found caverns and underground drains—the lines of those drains being marked upon the surface by sinks or depressions.

Whenever the drainage of this country cuts below this bed, and the dip is favorable, these underground drains pour forth the water which had entered at some higher point, in many cases several miles distant. The beds are frequently interrupted by cracks and water courses. I have proposed to distinguish them as the cavernous member of the Lower Silurian rocks of Kentucky. It is probable that these are the water-bearing beds reached by boring the Artesian well at Louisville—the waters of which are already so celebrated.

It had been predicted, before any considerable progress had been made, that the boring would reach upwards of two thousand feet before water would be obtained, the if beds outcropping to the east and south held the same thickness at Louisville which they had at these outcropping edges. This well of Messrs. DuPont is probably the deepest boring ever made in rocks of the Silurian period. It certainly is the

deepest in these beds made in the western States. The register of the materials was carefully kept, as also the coarser parts of the borings pumped up at different depths. The analogy between this record and that of the surface section kept on the base line, is sufficiently close, both as to thickness and the material brought up, to enable an expert to point out at the outcrop of the different beds as they came to surface—between Louisville and Dick's river.

On Cane creek, one mile west of Dick's river, the rocks are much more disturbed than at any point observed on the base line since the margin of the coal measures was left in Hancock county.

The rocks near the top of the Bird's-eye limestone are ruptured and tilted toward the west and northwest—between Cane creek and Dick's river, the angle of dip rising frequently as high as 15° to 18°. The gorge in which Dick's river flows is apparently an open fracture, since the rocks generally dip away from this river when the bends in the stream are sudden, except at the points coming forward into the bends, which are long and narrow; in such cases the point frequently falls or dips toward the river; but, even then, rocks on the opposite side dip, as usual, away from the stream.

It is not probable that the gorges in which Dick's and the Kentucky rivers flow are due to denudation; but it is a legitimate inference, from the arrangement of the rocks forming their sides, that these rivers flow in the lines of original fractures produced by the upheaving forces elevating these rocks from the place in which they were deposited to that which they now occupy.

Mr. J. E. Thompson states that the 171st mile post of the base line is near the center of the belt of blue ash, walnut, and sugar-tree land, which extends towards the north and crosses Kentucky river in the neighborhood of Munday's Landing, having an average width of two and a half miles. On the south side of the line this belt extends toward Danville, gradually spreading or extending in width, at Danville it being from 6 to 8 miles wide. The whole length of this peculiar soil south of Kentucky river being about 20 miles. The same belt of land extends north of the Kentucky river into Nicholas, Woodford, Bourbon counties, &c., expanding in width north of the Kentucky river.

This peculiar soil being produced by the decomposition of the limestones immediately above the cavernous member of the Silurian rocks,

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and the deepest seated rock of the upland country of middle Kentucky, its margin indicates precisely the form of the great anticlinal axis which divides the State. If this boundary was correctly defined, it would at once give the key to the dip over a vast extent of country, and determine nearly all questions in relation to Artesian wells. This is becoming a subject of considerable importance, in an economical point of view, in addition to its scientific interest.

The Bird's-eye limestone forming the walls of Dick's river is in compact thick ledges, from 2 to 6 feet thick, varying little in character for 175 to 200 feet.

The deepest cut rocks on the line are seen at the crossing of this river.

After crossing Dick's river the line lies for nearly six miles in Garrard county — the surface rock being composed of the beds near the top of the Bird's-eye limestone. On the 180th mile a considerable uplift is crossed. Where it was examined, the rocks on either side dip from a line to the east and west. Three fourths of a mile to the east a branch runs parallel to the Lexington and Danville turnpike. On this branch is seen a reversal of dip for a considerable distance on a west and northwest course. Approaching Kentucky river with the line of the branch the dip is seen gradually to change, and, finally, near the river, the dip is to the southwest and away from the line of the river. The greatest angle of dip observed being nearest to the river: the angle of the dip varying from 1° to 50°. The beds being, moreover, frequently fractured and slipped. The line of greatest fracture, or main axis of disturbance, lies on a course north 10° E, South 10° west. The mouth of the branch enters Kentucky river opposite Boon's knob, which is an isolated mass of the Bird's-eye limestone, 210 feet high, separated by the fault before alluded to, which crosses the Kentucky river near this point. The character of this disturbance is considerably changed on the other side of the river; the rocky masses on the west side appear lifted, while those on the east side are fallen forward and depressed. The axis of the fault on the north side of the river, so far as examined, coincides with the line of Big Hickman creek.

A remarkable disturbance in the rocks was observed on our return from the work of the base line, a few miles east of Winchester. It is not improbable that the fault at Kentucky river may be extended into

Clarke county, and this disturbance and that in Clarke may be cotemporaneous. The rocks disturbed in Clarke county are the yellow magnesian beds of the Upper Silurian date and the beds of black slate. These disturbances, if connected, would determine the geological period in which they occurred, and would doubless throw much light on the ancient coast lines of the different geological epochs ruptured by the fault or by a succession of disturbances. At all events, there is no doubt that the fault, and the lines of the Kentucky and Dick's rivers, which lie in the deep gorges of the Bird's-eye limestone, are cotemporaneous and produced by a common cause.

On the 181st mile, the line crosses the Kentucky river and enters Jessamine county. On the 182d mile, the line cuts a bend and crosses the river twice. The Bird's-eye limestone is no longer seen after entering Jessamine county, while the sandy and marly beds, equivalent to those on the west side of Salt river, prevail on the 165th mile, making a distance of 16 miles along the base line. The distance between these beds is probably greater both on the north and south side of the line. On the 185th mile, the Kentucky river is crossed the fourth time.

The land between the third and fourth crossing of the river is rolling, the hills rich and rounded, being composed of soft beds consisting of soft muddy sandstones, alternately with thin beds of marly clays and limestone. The mixture of the decomposed materials of these beds forms a soil very rich in all the elements required for farm crops, while it is friable and easily cultivated. The steepest hillsides are cultivated in corn and other plowed crops; yet such is the softness of the beds composing the hills, that the soil is kept up and restored by fresh disintegration for years on slopes from 30° to 45°.

From the fourth crossing of the Kentucky river to Richmond, (198th mile of base line,) we passed along a level country. Toward the west the lines of the creeks cut deeply into the soft measures lying between the magnesian limestone of Upper Silurian date, and the Bird's-eye limestone, and the equivalent of the beds spoken of as composing the surface rocks of Nelson, Washington, and Mercer counties. The lower beds of these measures, as seen in Jessamine, Garrard, and the western part of Madison counties, are softer than on the west side of the great anticlinal axis. No positive determination was made of the thickness of the soft measures alluded to, but they are believed to be thicker on

the west than on the east side of the axis. What part of the thickness is lost to view by the sinking of these beds on the east side of Big Hickman has not yet been determined. The rocks are more fossiliferous on the east than on the west side of the axis, and the fossils are less washed and broken.

Near the fourth crossing of the Kentucky river a thick bed of reddish limestone is seen in outcrop, about 70 feet above the river, filled with the remains of Isotelus platycephalus (gigas.) On the 195th mile considerable beds of sandstone are seen in ledges from 20 to 30 feet in thickness; the upper part of these beds having a number of thin beds of limestone intercalated. In some localities the beds are replaced by segregated masses of limestone which occupy their places.

The upper part of this member forms the surface rock in the N. E. corner of Garrard county, on the tops of the hills, locally capped by from 10 to 15 feet of marly clay. When this last bed caps the hills, their sides are frequently covered with a fine growth of black locust timber.

Under the sandstone beds at the fourth crossing of Kentucky river are about 200 feet of beds of alternations of limestone and marlite. Although the valleys are deep, and the sides abrupt, still accurate minute sections are difficult to obtain on account of the loose debris disintegrated from the soft materials composing the hillsides concealing the outcropping edges of the strata.

East of Paint Lick creek the line crosses a series of hills capped by wasted fossiliferous sandstone. These beds contain comparatively little lime, hence the soil is inferior to that derived from the decomposition of the beds lying below and farther west. The timber on the sandy beds is principally oak and hickory.

On the bottoms and slopes of the low hills on the west side of Silver creek, great quantities of quartz pebbles and geodes were observed covering the land and mixed with the soil. The pebbles were, doubtless, derived from the conglomerate lying farther south. The geodes are from the sub-carboniferous limestone; many of them containing characteristic fossils of that formation.

The rocks seen on Silver creek dip in the direction of the stream to the northwest, at an angle varying from 4° to 6°. The dip with the line of the branches and creeks from the 187th to the 196th mile is the

usual arrangement of the rocks. To the north about 10 miles, on the Kentucky river, the dip is reversed, and would form a synclinal fold, between Richmond and the Kentucky river. On the head of Tate's creek, near the Richmond and Lexington turnpike, (197th mile,) the upper beds of the sandy mudstones dip under the base of the yellow magnesian limestones, equivalent of the beds of Nelson county. Near Owingsville, Bath county, is a point west of which the yellow limestone is not seen.

East of Richmond the surface of the country gradually falls off in altitude, from the 198th to the 209th mile, when the Kentucky river is crossed for the fifth time. The valleys of the branches and creeks which cross the line, are not cut so deeply into the rocks between Richmond and the Kentucky river on the east, as they are on the west. The lands east are generally level; the rocks on the line have little or no dip, except locally. On the 203d mile the yellow or buff beds are well marked on the plantation of Mr. Peter Todd, where they are capped by sandy shales.

On the 204th mile, on the farm of Solomon Turpin, the white earthy beds, recognized as the equivalent of the beds near the favosites beds of Nelson county, are cut by the drains. The land is level; the soil whitish and swampy.

On the 205th mile the wasted beds of black slate are seen, capping elevated situations. Slips of the beds again bring to view strata which had previously disappeared below the surface.

At the Flatwood's Meeting-house the beds lie level. Near the sawmill of Mr. Henry Moore, search has been made for coal in the black slate beds which have been confounded with the bituminous shale associated with coal beds. It is quite impossible to obtain coal in the black slates and its inferior beds. The rocks intervening between it and the coal beds observed farther east, are several hundred feet in thickness, burying the black slate under the lowest coal beds to that depth. On the 210th mile, on the north side of Kentucky river, the point in the bend falls forward towards the river, and is capped with the knobstone, equivalent to the Waverly sandstone of Ohio, and the beds of the knobby country of Nelson, Bullitt, and Jefferson counties.

The 212th mile is located on hills covered by the waste of slate beds, and the lower part of the knobstone based on the yellow mag-

nesian limestones, which have considerable quantities of chert intercalated in beds and segregated masses. Small pieces of crystalized copper pyrites have been found in several places near the line in those beds. Several of the most noted localities of "copper" were visited; nothing was seen which would, in our opinion, justify expensive workings in any of these localities. The 213th mile post would come in the Kentucky river, which was crossed here for the seventh and last time.

The bank of the river, on the west side, rises into a perpendicular cliff, of which the following is a section:

No. 12. *Section at 213th mile post base line.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Black slate, top beds earthy, probably possessing hydraulic properties	130	-----	169	-----
Earthy limestone and chert beds	14	-----	39	-----
Limestone, gray and yellow	25	-----	25	-----
Bed of Kentucky river.				

The timber has suddenly changed in character. The waste on the hill tops of the knobs is covered by black pine and whortleberry bushes, or chesnut oak and red oak; the sides with laurel and pine.

From the 213th mile the "Mountains" are in sight. The highest of these *mountains* are generally from 600 to 650 feet above the drainage at the base.

The characteristic features of this formation are well marked here: the hills are steep and rounded; the outliers of the sub-carboniferous limestone and great sandstone at the base of the coal measures standing out in prominent, isolated hills beyond, and as high as the general mass from which they have been disjointed by the same force that elevated the rocks of the surrounding district; subsequently these outliers have been further severed from the parent rock by the action of running water seeking the deepest lines of fracture, and thus wearing away and undermining the softer layers upon which the more massive rocks repose, which, splitting at right angles to the bedding, finally are precipitated into the valley, leaving the remainder of the outlier standing with nearly vertical walls.

The pebbles of quartz of the conglomerate are strewed miles from the parent rock, having resisted the disintegrating agencies which have carried away the finer and more soluble earths.

The 213th mile lies on low hills of slate. The 214th mile crosses Calloway's creek. The 215th mile begins at the base of a pine-covered knob on the waste of the knobstone, crossing near the summit and ending on the benches at the base of the "Lone knob." The 216th mile rises the Lone knob at the north end, and cuts the summit at the edge of the precipice of sub-carboniferous limestone, which rises nearly to the extreme height at the north end. The summit, at the south, is capped by sub-carboniferous limestone; the north end by blocks of the great sandstone near the base of the coal measures. The sides of the knob are precipitous on the northeast and west sides. On the south it rises by a rapid slope. The height above the drainage at the base of it is, by barometer, 623 feet.

No. 14. *The following section is from the southwest side of the Lone knob, Estill county:*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandstone, in two benches, at north end of knob	12	......	623	......
Iron ore and earth, resting on limestone	10	......	611	......
Sub-carboniferous limestone, upper beds hard, and in ledges 8 to 10 feet thick	150	......	601	......
Knobstone and covered space, with a few ledges of hard sandstone cropping out	410	......	451	......
Shale beds, containing kidney-shaped masses of carbonate of iron	15	......	41	......
Black slate	26	......	26	......
Branch at foot of knob.				

The steepness of the hill being unfavorable to correct results by the Locke's level, the barometrical determination of the height is taken as being more reliable. Subsequently a carefully made detailed section of the sub-carboniferous limestone was obtained at Cottage furnace; by this section the limestones are found to be thicker than at the "Lone knob." I do not infer that the limestones at Cottage furnace were originally thicker than at the knob; but suppose that all the limestone at the knob may not have been included in the section above; the base of the mass was probably hidden from view at the knob.

The whole line from the 216th to the 235th mile crosses drains which cut into the limestone.

The following section obtained on the 218th mile will give the character of the beds cut by the branches of Cow creek, and especially the beds of sub-carboniferous limestone which are cut by all the drains on both sides of the ridge dividing the Kentucky and Red rivers from Cow to Lo Devil creeks, from the 218th to the 235th mile.

The character of some of these drains and gorges will be particularly described in a subsequent part of this chapter.

No. 12. *Section of the limestone of the sub-carboniferous beds, lying between the knobstone beds and the great sandstone at the base of the coal measures of Estill, Powell, Owsley, and Morgan counties:*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Thick, irregularly bedded sandstone; fine, sharp grit; remarkable for obliquity of lines of deposition, produced by currents from the N. E.	10	------	293	------
Thin bedded sandstone, sharp grit	11	-----	283	------
Whitish silicious shales, when first opened gray-lead colored, especially near the base	22	------	272	------
Place of ore beds.				
Gray shales	2	------	250	------
Buff thin bedded earthy yellow limestone, containing a few fossils; character not preserved	8	------	248	------
Thin bedded earthy limestone, containing Retepora, Archemides, and Pentremites	2	6	240	------
Thick bedded gray-drab limestone	13	------	237	4
Covered space, with aluminous and calcareous shales?	10	------	224	4
Whitish oolitic limestone, in flags, containing *Pentremites pyriformis* of large size	10	------	214	4
Buff limestone; upper part earthy and soft, breaking into irregular angular fragments	11	------	204	4
Semi-oolitic crystalline limestone, producing red earth by disintegration	22	------	193	4
Rough concretionary bluish-gray limestone	10	------	171	4
Gray limestone, with buff colored segregations	2	6	161	4
Bright buff colored earthy limestone, non-fossiliferous	4	6	158	8
Irregular thin bedded greenish-gray limestone, non-fossiliferous—the top of the bed having a few beds of chert	24	------	154	2
Base of Cottage furnace stack.				
Section below Furnace.				
Thick bedded limestone, semi-oolitic, upper part non-fossiliferous, containing beds and segregations of green flint, the lower part of the bed containing Pentremites, Crinoidea, Bellerophon, and remains of fish	22	------	130	2
Blue earthy limestone and shales, containing corals, Spirifera, Penbratular, Retepora, and Crinoidea	38	6	108	2
Soft earthy yellow limestone	56	------	60	6
Base of sub-carboniferous limestone.				
Section of Knobstone above Cow creek.				
Soft greenish silicious shale, (knobstone)	32	------	64	------
Hard beds of greenish sandy shale	16	------	32	------
Hard beds of fine grained sandstone	16	------	16	------
Bed of Cow creek.				

The sub-carboniferous limestone, by this section, appears to be 186 feet thick. The knobstone is cut by the drainage 64 feet below the limestone, at the place where the section was taken. At the point where the base line crosses this branch the knobstone is cut much deeper—about 300 feet. This section, with slight modifications, would apply to the sides of the numerous deep drains which the line crosses to the 235th mile; the cutting into the knobstone becoming gradually less and less to the head of Miller's creek, when the knobstone disappears under the superior beds; the head of the section gradually increasing by the additional thickness of coarse sandstone and conglomerate, until the conglomerate and associated beds attain a thickness of 243 feet—the sectional cuts made by the branches being kept up to about 400 feet. All the streams on the line have precipitous banks, either on one or both sides, from the 218th to the 235th mile. The valleys from the summit of one ridge to that of another vary from 1,400 feet to 3,500 feet. Of these drains, no less than forty were crossed in seventeen miles between the points referred to.

Our work, in crossing these abrupt valleys, was very laborious. Owing to the precipitous character of the walls of these valleys, it was necessary, in crossing them, either to head the valley or to find a break in the wall, on one side, by which to descend; making egress from the valley by some similar drain on the other side; but, since these drains were neither on the line nor opposite to each other, it was frequently necessary to walk from one to three miles to cross ravines only 2,000 feet wide. In addition to these difficulties, the sides of the drains were frequently grown over with underbrush, matted into a dense mass by vines growing amongst it.

The ridge dividing the waters of Kentucky and Red rivers, (the summit of which is also the dividing line between Estill and Powell counties,) and the continuation of the same ridge dividing Morgan and Owsley counties, frequently crosses the base line in its tortuous course towards the heads of the water courses by which it is eroded.

At the head of Miller's creek the ridge is interrupted and is no longer continuous. Miller's creek rises north, and the South fork of Red river south of the summit, thus throwing the highest ridge in lines nearly at right angles with the axis of the main ridge, which again assumes a continuous line on the east side of Miller's creek. The

course of this ridge deviates sometimes several miles from a straight line, the irregularities being sometimes in curves and sometimes forming the sides of an acute angle.

The "*Old Furnace*" of Estill county lies north of the 223d mile. The highest land found in the county lies half a mile west of the furnace, where the sub-carboniferous limestone comes nearly to the top of the ridge. The ridge is capped by the ore bed under the great sandstone before alluded to. At this locality the ore is associated with a thin coal from 2 to 6 inches thick. East of the furnace, near the 224th mile post, the coal of this geological horizon has increased in thickness to nearly two feet. It has been opened and wrought; but the supports of the drift have fallen in so as to make it at present inaccessible.

North of the furnace lies a fine example of the sandstone at the base of the coal measures. On the north side it is 235 feet in height. The summit of this rock is less elevated than the sub-carboniferous limestone half a mile to the south of the furnace. Between the furnace and the "State House"—a conspicuous cliff of this sandstone—the rocks are seen dipping to the north from 5° to 20°, with evidence of much slipping towards the north. The ridge along its whole length shows a dip on either side away from the ridge both to the north and to the south. The high land west of the furnace is dome-like, and the dip is also from it in all directions.

The materials at the base of the State House sandstone are found to vary remarkably in short distances.

The sandstone is usually found resting on beds of silicious shale, with locally thin bedded sandstone, which, when present, are found to be well marked by impressions of fossil plants. Under the sandy shale and sandstone thick beds of clay are found in certain localities, which is used as a fire clay at the old Furnace, and is reported to be of excellent quality. It is usually under the horizon of the fire clay bed that the ore bed is found. In some localities the clay and sandy shales are absent, and the ore is found resting on the water-worn surface of the sub-carboniferous limestone. The base of the "State House" sandstone, in such cases, is separated from the ore bed by a thin bed of clay or silicious shale. The modifications of these beds are numerous; the above mentioned are the most common. The ores are raised both by stripping and by drifting; the bed varying in thickness from 3 to 24 inches. Not having the time

at command, while carrying the base line through the territory where these beds are most favorably cut, the associate beds have not yet received the examination that their importance demands.

The 224th mile post falls near the corner of Powell county, in the Estill county line; the base line crosses to the north side of the ridge, within a few yards of the corner; after crossing one stream the line recrosses the ridge to the south side.

The 226th mile post falls on the slope of the hill, on the east side of Miller's creek, having crossed the branch called Lowry's branch of Miller's creek.

The 227th mile crosses to the north side of the ridge, and again lies in Powell county. The dividing ridge lies south of the line from the 227th to near the end of the 233d mile, making a great bend to the south between the 231st and 233d mile. From the 233d to the middle of the 236th the line lies in Owsley county. On the 230th mile the conglomerate sandstone attains its maximum thickness, and the hills are capped with soft beds lying above it. The drains and creeks cut the knobstone for the last time on the line on the 229th mile.

Eastwardly from the 229th mile the bends of the streams are nearly all at right angles, sharp and abrupt—the valleys walled by the mass of coarse sandstone, which is so prominent a feature on Baker's branch of Little South fork of Red river, Graining Block creek, and numerous nameless branches on the north side of the ridge; and on Miller's creek, Low Devil, and smaller streams on the south side of the ridge. Some of the walled sides of the Little South fork are said to be impracticable for seven miles, where it is walled in, nearly perpendicularly, to the height of 200 to 300 feet without a break. The same remark will apply to the valleys of the numerous branches of Graining Block creek. The head of the Hotel branch terminates abruptly against a cliff 250 feet high, the chasm being about the same width.

The base of the sandstone is frequently exposed from the 227th to the 234th mile; it was examined carefully on the line for the ore and coal beds of this horizon. The coal was seen in several valleys. The ore bed was not observed east of the 227th mile. North of the line, on the main branch of Graining Block creek, the coal is said to be four feet thick, (on the 233d mile.) On a branch of Red river, north of the 254th mile, three fourths of a mile distant from the line, the coal was

seen well exposed; it was only eighteen inches thick. At this locality no traces of the ore were seen.

The rocks begin to dip more rapidly toward the east on the 236th mile; and at the crossing of Swift's Camp creek the top of the conglomerate sandstone is seen for the last time, the level being much lower than at the head of Low Devil creek, where it is the surface rock. About 80 feet above the conglomerate is a sandstone, into which is wedged a coal, varying from a line to several inches in thickness. This bed is frequently parted and insinuated between the cracks of the rocks above the place of the bed. The sandstone varies, in different localities, from 15 to 35 feet. It is usually well marked by impressions of plants. The space between the conglomerate and this bed is filled with soft material, mostly covering the outcrop of the strata.

The parts exposed were composed of sandy and aluminous shale. When decomposed, these beds form a soil which produces well for a short time, especially in places where the surface is reasonably level. Near the top of the conglomerate, and at the base of the soft beds, is generally a belt of hemlock, and white and yellow pine timber; while the upper part of the soft bed supports a heavy growth of poplar, white oak, black oak, and black gum.

At the Spruce gap, at the head of Low Devil creek, the dividing ridge is very much depressed. It was through this "gap" that the original inhabitants passed on their journeys between Red and Kentucky rivers. The *old Indian trace* through Spruce gap is even now considered the best route between the two streams.

The soft beds referred to above, as lying above the conglomerate, are probably the equivalent of the shales of Little Sandy river, (see Vol. 2, page 351, Kentucky Reports,) given in the upper part of the section as being 100 feet thick. A more detailed section is now given on page 352. No coal beds were seen in this mass. The cuts on this part of the line are unfavorable for special sections. The hills of soft measures rise as high as three hundred (300) feet above the drainage, marked by two to four benches of harder materials. No beds of coal or iron ore are seen from the 237th to the 243d mile, which reaches and crosses Stillwater, a branch of Red river.

Considerable disturbance is again seen in the rocks on the east side of Stillwater creek. On the west side, on the farm of Mr. David Rose, the

first coal above the conglomerate is again seen—it is only 6 inches; five feet below the coal is a bed of compact silicious rock, containing from 4 to 6 per cent. of iron (?). Lithologically it is the exact counterpart of the silicious bed near the road at Star furnace, Carter county. This bed would fall into the section at Star furnace, given on page 353, Vol. 2, Kentucky Geological Reports, immediately above the Star furnace sandstone. South of 243d mile post the coal bed above referred to lies in the bed of the creek, at the old mill. The sandstone at the first locality which overlies the coal bed thins out in the distance of half a mile, and the coal at the second locality is covered by silicious shale.

On the farm of Mr. Abraham Swango, eastwardly of the second locality half a mile, the coal and sandstone are brought above the drainage, to be again carried down by a dip of from 5° to 15°. This rapid dip continues a very short distance, and at Mr. Adam Harmon's we have the coal, seen at Stillwater, again brought down to the level of the drainage. The hills from Stillwater to Lacey's creek, 243d to 246th mile, rise above the drainage from 180 feet to 250 feet.

The section of the base of these hills, so far as obtained, shows the same measures on both creeks.

Ascending the road branch of Stillwater creek one and a half miles, the dividing ridge between Stillwater and Lacey's creek is reached. The elevation above the three vein coal, in section No. 13, is 190 feet, divided into four benches or terraces. The road passing through a gap, the extreme height of the hill is not given.

The last section of these beds was obtained near Mr. Harmon's, as follows:

No. 13. *Section of coal measures on Stillwater, near the farm of Mr. Adam Harmon.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandstone bench	25	----	88	10½
Sandstone	1	6	63	10½
Sandy shale	3	----	62	4½
Coal	----	6	59	4½
Sandy shale	----	2½	58	10½
Coal	----	8½	58	8
Shale	----	6	57	11½
Coal	----	1½	57	5½
Bluish aluminous clay	4	----	57	4
Bluish aluminous clay, with fossils	2	----	53	4
Sandy shale	13	----	51	4
Thin bedded sandstone	20	----	48	4
Blue and black shale	18	----	28	4
Sandstone, thick bed	4	----	10	4
Coal, 4 to 15 inches	----	4	6	4
Shale, 4 to 6 feet	6	----	6	----
Sandstone, thin bedded; branch; equivalent of Star furnace stack sandstone.				

On the road line from camp on Stillwater, to Lacey's creek, two exposures of the section at Stillwater was seen on the waters of Lacey's creek.

The materials composing the hills between Stillwater and Gilmore creeks are soft; the hills rounded, and very steep.

Immediately south of the line, 247th mile, on Lacey's creek, on the farm of Mr. Jos. Rose, the following section was obtained; it appears to be the equivalent of section 13 at Mr. Harmon's, with the addition of the masses below, seen at Mr. David Rose's, on Stillwater, (243d mile.)

No. 14. *Section of coal measures on Gilmore's creek, on 248th mile, base line.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, occasionally showing beds of sandy shale	60	------	104	------
Coarse loose textured sandstone	8	------	58	------
Sandy micaceous shale, dark-gray and yellow	6	------	50	------
Bluish shale	1	------	44	------
Coal. Bituminous	------	6	43	------
Shale, (silicious mud)	8	------	42	6
Coal. Bituminous	------	7	34	6
Aluminous parting, clay	1	8	33	9
Coal. Shaly cannel or splint?	------	8	32	1
Ash colored shale	15	------	31	5
Gray sandy shale	1	4	16	5
Pyritiferous sandstone	2	10	15	1
Sandstone, thick masses	8	------	12	3
Shaly sandstone	1	8	4	3
Sandstone	1	------	2	7
Shale, lead-gray	------	2	1	7
Sandstone	1	5	1	5
Branch.				

The beds cut by the valley of Gilmore's creek are the same as those of Lacey's creek, Section 14. The section is not exposed quite so low on the latter as the former. The sandy shale and sandstone are near the foot of the hills, which receive an additional thickness of shale and sandstone upon the top. All the beds appear to be composed of coarser materials than further west. The hill land is becoming poorer as the materials become coarser.

On the 250th mile the hills, in a few places, on the highest points, are capped by a bed of sandstone about 20 feet thick; the ridge north of the 251st mile, the divide between the head of Johnson fork of Licking and Red river, is capped by this last rock. Immediately beneath the sandstone capping the ridge is a bed of iron ore; judging from surface indications, the bed is from 18 to 20 inches thick; the ore appears to be of good quality. The extent of this ore bed was not ascertained; it appears on most of the ridges between the Road fork and main Red river, above Widow's creek; extending east and northeast, disappearing to the south and southwest; the hills in the latter direction being capped by measures lying beneath the ore bed.

Between the first and second branches of Johnson fork of Licking the sandstone caps the top of the hill; the measures beneath it being

quite soft, while the sandstone is quite hard, it has been undermined, and immense blocks of it are broken and tilted toward the valley. Some of the blocks are from 30 to 40 feet in length, 25 to 30 feet wide, and 20 feet thick—being remarkable objects; capping, as they do, high very steep hills, composed of softer materials, which in many places are not sufficiently wide to receive one of them on the top without part of the block projecting over the sloping sides.

The valley of Wheelrim fork of Johnson cuts below the tops of the hills from three hundred and forty (340) to three hundred and seventy-five (375) feet. At the crossing of this branch, near Mr. Elam's, the following section is seen:

No. 15. *Section at the crossing of Wheelrim creek,* (255*th mile.*)

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Steep hill, in three terraces, capped by waste of "top hill rock"	312	------	347	------
Coal. Bituminous	------	6	35	------
Gray sandy shale	4	------	34	6
Coal	------	7	30	6
Sandy and aluminous shale	1	3	29	11
Coal	------	8	28	8
Sandy shale	7	------	28	------
Sandstone	2	------	21	------
Shale, sandy	14	------	19	------
Micaceous sandstone and shale	5	------	5	------
Bed of Wheelrim branch.				

There can be no doubt as to the equivalency of these with the beds at Lacey's creek. The same beds as those of this section are seen on Johnson's fork for several miles, variously modified in a few feet as to the thickness of the coal and the separating masses. On the face of the same cliff the changes are sufficient to alter every figure in the section.

On Johnson's fork, at the "Rock House," the following section is cut:

No. 16. *Section at "Rock House," on Johnson creek, north of 254th mile, base line.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandy shale, lead-gray	25	------	25	8
Bituminous shale	------	4	6	4
Gray sandy shale	1	8	6	------
Coal. Bituminous	------	8	4	4
Bituminous shale	------	5	3	8
Coal	------	8	3	3
Under clay	1	7	2	7
Gray sandy shale	1	------	1	------
Bed of creek.				

The hills south of the place of this section, as determined by barometer, are 350 feet in height above the drainage. The tops of some of the ridges receive the ore bed and the sandstone above it.

The measures on the east side of Wheelrim creek are divided into three benches, above the top of the shale beds at the top of section 16.

The upper of these benches, or terraces, is capped by a slope lying under the top hill sandstone and ore bed. The hill may be divided as follows:

No. 17. *Section east side of Wheelrim creek,* (255*th mile.*)

	Thickness.		Elevation.	
	Feet	Inches.	Feet.	Inches.
Covered space, principally shales, with capping of sandstone	88	7	254	10
Covered space, to top of terrace, (2d)	18	------	166	3
Covered space, sandy shale, with a few plates of sandstone	122	7	148	8
Top of shale in *section* 16.				
Section 16	25	8	25	8
Bed of branch.				

The dip to the northwest with the valley in one mile is equal to 95 feet, as the rocks are slipped toward the line of the great streams and from the dividing ridge. No fault was observed after a careful examination; the dip being apparent on Johnson's creek, east of this place, carrying the section at the head of the valley to nearly the same height above the branch for four miles down the stream, which has a rapid fall.

The line from the 255th to the 258th mile post lies along the spurs and breaks, into the valley of the Long branch of Johnson fork, lying on the same measures.

The 259th mile enters the breaks and crosses the valley of Cow creek. On the 259th and 260th miles the hardening of the measures of section 17, is quite manifest; the slopes beneath the terraces frequently present benches of compact, coarse sandstone, from 5 to 10 feet thick.

Near the line on the Middle fork of Licking river the beds rise above the creek, and a section was obtained from Middle fork to the top of the ridge east of Cow creek.

By barometer the height of the ridge is 314 feet. The thickness of the different members composing it are as follows:

No. 18. *Section of hill between Middle fork of Licking river and Cow creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, 15 to 25 feet	15	------	280	------
Shales and ore bed	5	------	265	------
Sandstone and hard sandy shale, from 80 to 100 feet thick	90	------	260	------
Whitish silicious clay	8	------	170	------
Loose coarse sandy shale	75	------	162	------
Black bituminous shale	2	6	87	------
Bituminous coal, 26 to 28 inches	2	2	84	6
Compact sandy shale	10	------	82	4
Sandstone	30	------	72	4
Sandy shale	9	------	42	4
Coal, 4 to 6 inches thick	4	------	33	4
Sandy shale, 7 to 9 feet	8	------	29	4
Sandstone, marked by fossil plants, thin sheets of coal injected	6	------	21	4
Coal	------	4	15	4
Sandv shale in slope, partly covered	15	------	15	------
Middle fork.				

The masses of rock by their united thickness make only 280 feet; while the height of the hill is three hundred and fourteen (314)—a difference of 34 feet—there being that amount of dip in the length of the section. The direction of the dip is east. The west side of the ridge gives nearly the same result; the measures are not quite so well exposed, and the dip, being more rapid, the measures at the base of the section on Middle fork are carried below the drainage on Cow creek.

The line between Middle fork and Licking rivers lies over hills which

are not sufficiently high to receive the ore bed and the sandstone over it. At one point on the divide the wasted blocks of the top hill sandstone was seen. East of Gardiner's branch the hill has lost in altitude and materials.

The following section exhibits the characters of the mass of the hill at 263d mile post:

No. 19.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of hill.				
Sandstone, separated into 3 masses by shale beds, 4 to 6 feet each	88	------	145	8
Dark lead-gray and dove colored shale	57	8	57	8
Bed of Gardiner's branch on shale bed.				

To this section, on the 264th mile, near Licking river, the same beds are cut about 30 feet deeper than at Gardiner's branch. In the mass of shales near the top of 57 feet, section 19, a coal is seen on Licking river. Near the water, 71 feet below, a thin coal is seen. The shales below the sandstone, section 19, have increased in thickness regularly, from the west toward the east. On the waters of Licking and Burning fork, they are modified by the intercalation of limestone, either in interrupted beds or segregated masses.

Occasionally the shale beds are less earthy, and run into sandstone beds of greater or less thickness. The intercalated beds of limestone in the shales at Licking river, and in the valley of Burning fork, produce a corresponding change in the character of the soil and timber—the forest on the wasted shale in limestone beds being beech, sugar-tree, ash, buckeye, linn, &c.

The following section is from the north side of the valley of Burning fork, near the house of Mr. John Prather, (267th mile):

No. 20.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Coarse sandstone, usually covered by pine forests	30	——	159	9
Sandy shale, gray and yellow	38	——	129	9
Black shales, with thin coal, (sugar-tree horizon, limestone?)	17	——	91	9
Sandy shales	40	——	84	9
Heavy masses micaceous sandstone	16	——	44	9
Bituminous shale	1	2	28	9
Bituminous coal	11	——	27	7
Silicious under clay	1	8	26	8
Sandy shale, with a few beds of thin fleecy stones	16	——	26	——
Dark-gray shale, (micaceous)	10	——	10	——
Bed of branch, near Camp.				

The hill is distinctly divided into three terraces, with steep slopes between them.

The coal at 27 feet 7 inches is pyritiferous, and entirely useless. The shales at the base of section are doubtless the equivalent of the upper part of the 57 feet 8 inches of the shale bed at the base of section 19. The shale beds at Licking are remarkable for their softness, great thickness, and dark color. They are recognized in all the deep valleys from Licking river to the 278th mile, (13 miles.)

One and a half miles west of the place of section 20 a coal is in sight, near Adamsville. It is probably the 11 inch coal, at the base of section 20, which is thicker locally than at the place of the section.

The dip from the head to the mouth of Burning fork is to the west, and with the line of the stream. The distance is six miles; the same beds being cut the whole length of the valley.

The beds of iron ore do not appear in the valley of Licking and Burning fork; occasionally nodules of carbonate of iron are found in the drains, derived, apparently, from the shale beds beneath the coal, at 27 feet 7 inches, section 20.

On the 267th mile the line crosses the road from the lower counties to Prestonsburg, and continues north of it to Big Sandy river. The road rises the ridge at the head of Burning fork by a gentle slope, crossing through a low gap; the separation between the waters flowing into Licking and Big Sandy is hardly apparent. The line lying farther north passes the ridge at a rounded pinnacle in the ridge, at the head of the Rock Lick branch, a tributary of Burning fork. At the head of

Rock Lick the drainage is on the coal, at 91 feet 9 inches, section 20, rising, by a steep grade, a hill 254 feet high, capped by the 20 feet of heavy sandstone seen at the head of Johnson fork of Licking. The ore bed under this rock was not seen at this point. Along the line of Rock Lick the lower coal (at section 20) has a thickness of 20 inches; the coal above, in same section, being represented by from 5 to 6 inches of bituminous shale. On the 247th mile these beds are separated by only a few feet of sandstone. The rock separating these beds here has the same general character of the rock supposed to occupy this horizon, seen on Lacey's creek, Johnson and Wheelrim creeks. If this deduction be the true one, the Licking shale beds are the equivalent of the soft measures seen at Swift's Camp, immediately above the great sandstone.

The hill dividing the waters of Licking and Big Sandy becomes much raised, not by the addition of other rocks, but by the local elevation of the whole country. The beds of coal appear gradually to increase in thickness, subject, however, to many local changes.

The sandstones are better defined, and it is probable that the shale bed immediately above the great sandstone is thicker than when it is first seen on Trace fork of Stillwater creek. The hill top sandstone, as found at the head of Red river, is a most unmistakable horizon. The rocks lying below it differ widely, both in composition and division, even in quite short distances, rendering sections taken of the same bed in different outcrops, in the same hill, dissimilar in thickness and material.

The head branches of Middle creek, Green Rock fork, and South fork of Jenny's creek, falling into Big Sandy, head within a few yards of each other. Rock House fork heads east of the ridge, at the head of Rock Lick creek, and runs toward the north for a mile, when it turns abruptly to the west and passes through a gap in the ridge. On the south of the line the valley of Middle creek, within two miles, is 445 feet below the top of the capping rock, at the head of Rock Lick.

Eastwardly, on the 276th mile, the valley of Jenney's creek is 611 feet below the same point; a very considerable amount of this sum is due to dip.

The 30 inch coal seen at A. J. Rice's dips with the line of Jenney's creek, in half a mile, between Mr. Rice's and Mr. Payne Patrick's, 37 feet, about equal to the fall in the creek between the two points.

At the 272d mile post the top of the ridge is covered with the iron ores of the bed under the sandstone, equivalent to the sandstone seen at the Red river, Johnson's fork, Middle fork, and the head of Rock Lick creek.

This sandstone is, doubtless, the equivalent to the sandstone lying immediately above the Baker bank, Laurel furnace, the coarse sandstones capping the head of Cole and Alcorn creeks, the conglomerate lying over the Carrington and Highton banks, near Steam furnace, Greenup county, and the sandstone at the top of section at Clinton furnace, (page 362, Vol. 2, Kentucky Geological Reports.)

On the 273d mile, near Jenney's creek, we have the following section:

No. 21. *Section on farm of Mr. A. J. Rice, (273d mile.)*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of low hill.				
Wasted shale bed	20	------	125	6
Sandstone	35	------	105	6
Bituminous shale	------	8	70	6
Coal	3	------	69	10
Silicious under clay	------	10	66	10
Sandy shale	18	------	66	------
Sandstone	8	------	48	------
Sandy shale	6	------	40	------
Sandstone	8	------	34	------
Gray sandy shale	18	------	26	------
Sandstone	3	------	8	------
Bituminous shale	------	8	5	6
Coal	------	10	4	10
Sandy gray shales	4	------	4	------
Bed of Jenney's creek.				

The shales at the base of the above section and upward, to 69 feet, are doubtless the equivalent of the beds on the east side of the river, at the crossing near Licking Station.

The dip at the place of section is eastwardly. There are many changes in the direction of dip, running for short distances. The rocks are laid in waves; the apparent dip is, therefore, in various directions, the general direction being to the east or southeast.

The shales are probably increased in thickness at the base of the coal measures. The sandstone beds are becoming much better defined, and the coal beds have increased in thickness. The three feet coal (section 21) has a good roof; the face of the coal presented to the eye appears to be free of pyrites, and of excellent quality.

The line on the 273d, 274th, and 275th miles lays in the valley or on the spurs of main Jenney's creek—the 276th mile ending on the ridge dividing Middle creek from the main creek. The 277th mile crosses a high ridge between Middle creek and the East branch.

The ridge embraces no new measures. The hills are remarkable only for steepness, and the increased thickness of the shale beds, and for the better definition and less thickness of the beds of sandstone.

Half a mile south of the 278th mile, the following section lies near the bed of the creek:

No. 22. *Section on the east branch of Jenney's creek, south of the line half a mile.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandy shales	45	------	111	1
Sandstone	30	------	66	1
Sandy shale, 1 to 2 feet	2	------	36	1
Pyritiferous sandstone	------	8	34	1
Black bituminous shale	------	10	33	5
Iron ore, 2 to 4 inches	1	4	32	7
Coal	2	6	32	3
Under clay	1	------	29	9
Sandy shale	15	------	28	9
Clay and bituminous shale	8	------	13	9
Coal	------	6	3	6
Shale	1	------	4	6
Coal	------	6	3	6
Sandy shale	3	------	3	------
Bed of branch.				

The dip is very rapid toward the northeast; rapidly running under the beds at the base of section; the line crossing the branch on the bed near the coal at 32 feet.

INSTRUCTIONS

FOR SIDNEY S. LYON FOR THE PROSECUTION OF THE TOPOGRAPHICAL SURVEY OF KENTUCKY, IN THE YEAR

1859.

You will complete the base line; running it, as heretofore, from your last station near the mouth of Little Paint creek, near the corner of Johnson and Floyd counties, due east to the Virginia line.

You will select for this work the part of the season most favorable for your operations on the line—taking advantage of the high water of Big Sandy for the transportation of your supplies and camp equipage up to Prestonsburg, or other point on that river, most convenient to your starting station.

You will also connect the base line in Hardin county with the surveys in Hopkins county, along the eastern margin of the western coal field, through the counties of Breckinridge, Edmonson, Hart, Butler, Muhlenburg, Christian, and, probably, Warren, so as to define that boundary line.

You will also make such surveys as may be necessary to connect said base line in Hardin county with the surveys in Hancock county, and thence to the Ohio river, so as to complete the eastern outline of the western coal field, from the point of intersection near the confluence of the Ohio river and Tradewater, to near Hawesville, on the Ohio river, in Hancock county, around the circumference of the entire western coal field.

If time and means permit, you will also complete the Topographical Geological Survey of Hancock county—so as to construct the map of that county on the same scale and the same plan as that already executed of Hopkins county.

You will bring your field work to a close in time to complete your

plotting of the Topographical work, and write up your Report by November, 1859, as well as to finish any other office work connected with your department of the Survey.

You will also furnish me, in October, 1859, with a synoptical report of your entire surveys, made during the years 1858 and 1859.

D. D. OWEN.

CHAPTER II.

REPORT OF THE OPERATIONS OF 1859, ON AND NEAR THE MARGIN OF THE WESTERN COAL FIELD OF KENTUCKY.

The work of the season began on the Ohio river, at Stephensport, Breckinridge county, extending into Breckinridge, Grayson, Edmonson, Hart, Warren, Butler, Logan, Todd, Christian, Muhlenburg, Hopkins, Ohio, and Hancock counties.

By my instructions, I was required to extend the work of this season so as to enable me to lay down the margin of the western coal field of Kentucky.

The lines have been extended into the counties above enumerated, and a skeleton map is constructed on which is laid down the geological measures, forming the surface rock, when intersected by the line of survey.

The party under my direction began its field operations on the 21st of April, and closed on the 12th day of July. During the early part of the season the work was somewhat retarded by continued and heavy rains; notwithstanding which, the party has been able to accomplish during the time they remained in the field, 482 miles of line.

A greater part of the region in which this work had to be done is the roughest country in western Kentucky. The margin of the coal field in western Kentucky is, as you are well aware, surrounded by the millstone grit sandstones and the intercalated beds of limestone and aluminous shales; usually dipping at a considerable angle. These formations worn into deep ravines, by most of the water courses, produce a broken country, while the interval between the streams is usually filled with steep, rocky hills. Within this margin of millstone grit the surface is generally more level, since the beds of the coal measures are spread out with a dip, becoming gradually more gentle from the margin toward the centre of the basin, with which the surface of the country generally conforms.

To define the margin of the coal measures, which was the principal object of the work of this season, the surveys were mostly located in or near the belt of the millstone grit, and associated limestones.

A familiar acquaintance with the several beds of the millstone grit, became of the first consequence to enable me to direct the work in such a manner as to accomplish the immediate object of the work of this

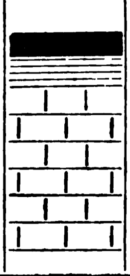
season as rapidly as possible, and confine it to as narrow a belt of country as practicable. In consequence, however, of the impracticable character of the country, and the want of roads along my line of observation, many considerable divergences became necessary on either side of the exact boundary line to be defined; rendering it frequently necessary to run around a country instead of passing through it; which, if practicable, would more effectually have accomplished the purpose intended, *i. e.*, to define the margin of the western coal field.

The surveys previously begun in Union county had been extended into Crittenden, Caldwell, and Christian counties; now it was necessary to extend them through the northern part of Todd, Logan, Butler, Warren, Edmonson, the western part of Hart, the southern and western part of Grayson and Breckinridge, to the Ohio river.

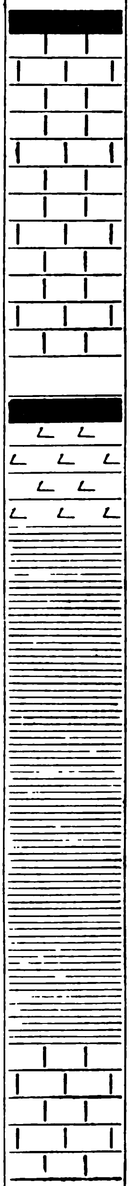
The coal measures on the north and east side of Green river were found lying on the tops of the ridges and table-land. The branches and creeks cutting through them have carried portions of them away, leaving occasional patches and outliers on the ridges between the streams.

Before entering upon the details of this survey, the following section of the millstone grit, and the limestone intercalated with it, will be given. The beds of this section will be designated in this chapter by the numbers here severally attached to them. No cut was found on the margin of the basin which gave the whole section; it has, therefore, been constructed of two or more sections joined together—reference of locality being made to the place of each part of the section:

No. 22. *Section of the Millstone grit beds, at the margin of the Western coal field of Kentucky, in Hancock and Breckinridge counties.*

Material.	Thickness.		Elevation.		
	Feet.	Inches.	Feet.	Inches.	
	1	6	511	8	Place of Breckinridge coal, Hancock co., under clay and sandy shale.
	40	......	510	2	Soft yellow sandstone.

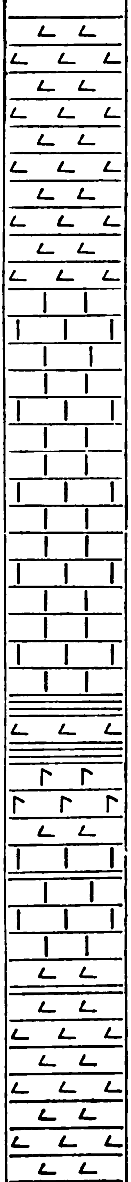
Section No. 22—Continued.

	Material.	Thickness.		Elevation.		
		Feet.	Inches.	Feet.	Inches.	
Fifth Sandstone.						Place of coal, (local.)
						Upper Tar sandstone, (local.)
		50	------	470	2	Heavy sandstone.
						Conglomerate, (local,) equivalent to the "Shot Pouch Sandstone," 2d Vol. p. 88.
Fourth Limestone.						Place of thin coal, (local,) generally dark shale.
		10	8	420	2	Steep covered space, limestone, (?) See Dia. No. 4, Vol. 1, Ky. Geol. Reports.
		84	------	410	2	Aluminous shale.
Fourth S. S.						Sandstone, thin beds, hard, fossiliferous, from 4 to 45 feet thick, (local.)

Section No. 22—Continued.

	Material.	Thickness.		Elevation.		
		Feet.	Inches.	Feet.	Inches.	
Third Limestone.		30	......	326	2	Limestone, containing Productus and Crinoides. (Locality, King's Hill.
		37	......	296	2	Limestone, containing Belerophon.
		53	4	259	2	Covered space, occasionally showing aluminous shales.
						The base of the mass aluminous shale.
		13	8	205	10	Limestone in thick beds.
		11	.....	191	2	Aluminous shales.
Third Sandstone.		16	......	180	2	Thin bedded sandstone, Tar Sandstone.
		14	8	164	2	Thick bedded sandstone, Tar Sandstone.

Section No. 22—Continued.



	Material.	Thickness. Feet.	Thickness. Inches	Elevation. Feet.	Elevation. Inches	
Second Limestone.		37	4	149	6	Yellowish gray limestone; thin beds. Buff limestone, (local.) Chert beds, (local.) Oolitic, (local.) White limestone.
Second Sandstone.		20	------	112	2	Coarse sandstone.
		62	2	92	2	Coarse sandstone; oblique beds of deposition; 4 beds. Lower Tar Spring Sandstone, of Breckinridge county.
First Limestone.		3	------	30	------	Marly shale containing lenticular masses of limestone.
		1	6	27	------	Limestone.
			6	25	------	Blue gray marl.
		15	------	25	------	
First S. S.		10	------	10	------	Fine grained sandstone, 10 to 35 feet thick.
						Cavernous member of sub-carboniferous limestone.

The Topographical Geological Survey begins at Stephensport, Breckinridge county, on the Ohio river, on the cavernous member of the sub-carboniferous limestone, (section 22.) The hills near the Ohio river rise rapidly, and include sandstones and limestones Nos. 1 and 2, the hill being capped by sandstone No. 3 in a few places; the various changes in these beds may be seen by the several sections on the lines traversing Breckinridge, Grayson, and Edmonson counties.

On the east side of the mouth of Sinking creek the cavernous member of the sub-carboniferous limestone is in sight, while the beds on the west side are covered by the wasted materials of the same beds at their outcrop, and those lying above in the hill, concealing the lower part of the section. Half a mile south of Stephensport, the lower part of the hill, on the west side of Sinking creek, is made up of hard and soft material, producing two distinct terraces. From the top of the terraces to the top of the hill, we have the following section:

No. 23. *Section south of Stephensport, Breckinridge county, half a mile from the Ohio river.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of hill.				
Covered space	30	------	291	2
Yellow sandstone, with yellow aluminous spots, (in cavities?)	22	------	261	2
Covered space	54	------	239	2
Limestone, upper part earthy	15	------	185	2
Earthy ash-colored shale	16	------	170	2
Sandstone	20	------	154	2
Pentremital limestone	8	------	134	2
Thin bed of limestone	1	3	126	2
Gray limestone	3	------	125	11
Sandy mud bed	2	11	122	11
Limestone	10	------	120	------
Covered space to bed of Sinking creek	112	------	112	------
Bed of Sinking creek.				

The hill is farther increased by the addition of superior beds; and at Mr. Thompson Greene's the hills are, by barometer, 413 feet high, or 122 feet higher than top of section, rising into the shales and limestones of No. 3, equivalent to the beds of Grayson Springs, Falls of Rough creek, and the beds above and at the base of the Nolin furnace. The triangular Bryazoa found in such abundance and perfection at the falls of Rough creek, was recognized here. It has a short, vertical range, and

has been found only in the upper part of the beds of the 3d limestone.

The same beds are seen on the road between Lewisport and Harrodsburg; the dip is quite irregular. Though the same beds are seen between these two localities, there are certain modifications of the materials worthy of note. The bed of limestone No. 2, at Mr. John Elder's, receives upon it a thick bed of aluminous shale and marlite. A well having been sunk in these shales at Mr. Elder's, the water was found to be so much impregnated with alumina and sulphate of iron (copperas) as to be unfit for use; even the cattle refuse to drink it. In the waste of the materials dug from this well are to be found crystals of sulphate of lime.

The land upon these beds is rolling; generally heavy timbered with white oak, poplar, sugar-tree, gum, &c.

The line crosses a ravine at 40,940 feet from Stephensport, in which is exposed a thin plate of Productus limestone, a part of limestone No. 2. This bed is seen at the crossing of Clover creek, and again in Hardin's creek valley. It has been seen in no other part of the millstone grit beds, and is probably quite local.

About five miles south of Stephensport the road crosses a deep synclinal fold in the rocks, the deep valley cutting only to the top of the 2d limestone.

The following section shows the change in the beds of the 2d limestone, as seen in the cut immediately north of Hardinsburg:

No. 24.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, (sandstone No. 3)	22	------	106	3
Aluminous shale	6	------	94	3
Semi-oolitic limestone	10	4	84	3
Yellow earthy limestone	15	8	77	11
Crystallized limestone	10	------	62	3
Covered space, soft sandstone, top of sandstone No. 2	48	3	52	3
Sandstone	4	------	4	------
Hardin's creek.				

From Hardinsburg southward, toward Winchell's mill, the rocks are quite horizontal; the surface rock generally being beds of sandstone No. 3, with occasional patches of limestone No. 3. These patches of

limestone No. 3 occupy usually only a few acres in extent, presenting the appearance of a flat knoll.

The soils surrounding these knolls of limestone are modified by the addition of lime, derived from the beds in the knolls; a change of timber invariably marks the margin of the influence of the lime beds.

The upper part of sandstone No. 3, on the line before alluded to, is in thin beds, fine grained, decomposing rapidly. The lower part of the mass being a thick bedded, hard sandstone, resisting atmospheric influence well; it stands out when cut in a bold escarpment.

The chemical character of the whole mass is not such as to produce fertile soils by decomposition. The lack of phosphate of lime may be supplied by the fossiliferous limestones lying both above and below it; the lower bed being cut into by nearly all the drains crossing the road.

Tewell's branch cuts through limestone No. 2 at the road, and runs on the top bed of sandstone No. 2. On the south side of the branch the dip is strongly marked 3° to 4° to the north.

The bed of the North fork of Rough creek, east of the road, presents considerable disturbance.

No. 25. *Section on north side of North fork of Rough creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Coarse sandstone, conglomerate, (5th sandstone)	30	------	274	8
Sandy shale, with thin coal markings	2	------	244	8
Sandy shale	14	------	242	8
Earthy yellow limestone	1	6	228	8
Crystalized limestone, *Pentremites*, &c	2	------	227	2
Limestone, partly covered	38	------	225	2
Covered space	74	------	187	2
Sandstone	21	6	113	2
Pentremital limestone	22	------	91	8
Limestone talus	26	8	69	8
Thin bedded sandstone	16	------	43	------
Heavy sandstone	16	2	27	------
Covered space	10	8	10	8
Bed of North fork of Rough creek.				

A trough occurs between Tewell and North fork of Rough creek; the hills and table lands are about the same in altitude as the table north of Tewell's creek.

The base of the 5th sandstone is first seen at one and a half miles

of North fork. The second sandstone lies near the drainage on the south side of North fork, dipping rapidly toward the creek. On the north side of the creek, at the place of Section 25, the rocks dip to the north as far as they are exposed. The beds of the branches flowing into the North fork show frequent waves and interruptions of dip.

The hill on the south side of North fork is ascended on the sloping mass of sandstone No. 2, which becomes the surface rock for some distance.

At the farm of Mr. Spencer the road ascends the 2d limestone and the 3d sandstone, capped by an outlier, or isolated patch, of the 3d limestone. The 3d sandstone then becomes the surface rock to McDanielsburg; from which point to Rough creek, at Winchell's mill, the drains and branches lie in beds mostly on limestone No. 2 and the upper beds of sandstone No. 2. Near Rough creek a small patch of limestone No. 3 caps the tops of the ridge, on which the road lies. In no part of the route on the south side of the North fork of Rough creek has the waste of the 5th sandstone, or any bed of it, been seen.

The beds of limestone Nos. 2 and 3, which are cut by drainage and denudation, near Rough creek, show the action of rapid currents during their deposition; the fossils are generally washed and broken. The triangular Bryazoa of the falls of Rough was seen in limestone No. 3, three quarters of a mile from the mill.

The rocks are much disturbed and fractured near the mill. Immediately above the road crossing the rocks are the cavernous beds of the sub-carboniferous limestone. On the north side of the creek they are tilted at an angle of from 8° to 20° toward the northwest. This dip continues for some distance up the creek, rapidly bringing to the light the sub-carboniferous beds.

On the south side of the creek the beds, from the sub-carboniferous limestone upward, are well exposed; they exhibit the unmistakable evidence of disturbances in the cavernous member of the sub-carboniferous limestone previous to the deposition of sandstone No. 1. The limestones of the former bed are cracked and slipped, forming deep notches between the standing and the slipped parts of the bed; the surface of the beds is water-worn, and the upper angular corners are rounded. Upon this worn surface, and into the notches, the thin, flag-like beds of sandstone No. 1 are deposited; several of the first beds

being required to fill the vacancies occasioned by the sunken part of the limestone. The ends of the first beds abut against a perpendicular wall of it; after the cavities are filled, the beds are continuous over the bed previously deposited and the higher parts of the limestone beneath it.

No. 26. *Section of sub-carboniferous limestone and millstone grit beds, north side of Rough creek, at Winchell's mill.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, dark clay shale	21	8	245	8
Limestone	18	------	214	------
Thin bedded sandstone, (probably slipped)	5	------	196	------
Limestone	25	------	191	------
White clay	14	------	166	------
Sandstone, in heavy beds	60	------	152	------
Thick bedded limestone, very few fossils	20	------	92	------
Silicious clay	12	------	72	------
Fine grained sandstone	10	------	60	------
Three ledges of limestone, (sub-carb.)	50	------	50	------
Rough creek.				

From 50 feet to bed of creek, belongs to the cavernous member of the sub-carboniferous limestone; 50 to 72, 1st sandstone; 72 to 92, to 1st limestone; 92 to 166, 2d sandstone, equivalent to the lower Tar Spring sandstone of Breckinridge county; 166 to 214, 2d limestone, increased in thickness. The hills near by contain superior beds to those at the top of section; they are not added because they are so much slipped and disturbed that they cannot be satisfactorily measured.

The waters of the creek being so much swollen that crossing was not possible, the line was retraced to McDanielsburg, and taken up at the forks of the road leading toward the Sulphur Springs, on the North fork of Rough creek. From the forks of the road to the Sulphur Springs the land lies level for two miles, when it rapidly falls off toward the creek, carrying down all the measures, in half a mile, about 100 feet. At the foot of this slope, limestone No. 2 is the surface rock. The rocks between this point and the Springs are broken into faults and waves. Near the Spring one of these waves is cut in section by the creek valley. A small branch flows into the North fork in the trough. The dip is from the main creek up the valley of the branch, which flows on the upturned edges of the rocks, which dip rapidly under its

bed. Sandstone No. 1 caps the mouth of the branch valley; the limestones beneath are of the cavernous member of the sub-carboniferous. The Sulphur Spring rises in the bed of the main creek.

The strong dip here is nearly south; the direction of the dip at Winchell's mill is northwest; in both instances dipping away from the line of the creeks. The dip at North fork varies from 15° to 35°. On the north side of the creek, near the Sulphur Spring, the dip is less rapid; 5° to 15° toward the southeast; and away from the bend below the Spring, and toward the bend above it.

The rocks between Rough creek and Eskridge's ferry are all the beds of the millstone grit; the 5th sandstone capping the "Sand knob" near the farm of Mr. Owens.

From Eskridge's ferry we have the following section—the thickness of the beds determined by barometer:

No. 27. *Section from Eskridge's ferry to top of "Sandstone knob." Horizontal distance, one and a half miles.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, conglomerate in lower beds	145	------	427	7
Covered space, showing shales, limestone, and sandstone at the base	134	7	282	7
Sandy shale and limestone	94	------	148	------
Covered space, heavy bed of limestone on top; part of sandstone showing near middle	54	------	54	------
Bed of Rough creek.				

Crossing at Eskridge's ferry, the work enters Grayson county.

The first elevation after crossing Rough creek is a steep rocky bluff of 45 to 50 feet; the base and middle of the mass consisting of the beds of limestone No. 2; the upper part being the lower beds of sandstone No. 3.

Notwithstanding the many reversals of dip the beds are falling toward the southwest; the 3d sandstone being at least 200 feet lower than the equivalent bed at Winchell's mill and McDanielsburg.

The shale beds associated with limestone No. 3 have been found to diminish in thickness from Clover creek eastwardly; they are found to be thickening to the southwest.

From the ferry to the falls of Rough and the Litchfield road the land is

being required to fill the vacancies occasioned by the sunken part of the limestone. The ends of the first beds abut against a perpendicular wall of it; after the cavities are filled, the beds are continuous over the bed previously deposited and the higher parts of the limestone beneath it.

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Thick bedded limestone, very few fossils	20	-----	92	-----
Silicious clay	12	-----	72	-----
Fine grained sandstone	10	-----	60	-----
Three ledges of limestone, (sub-carb.)	50	-----	50	-----
Rough creek.				

From 50 feet to bed of creek, belongs to the cavernous member of the sub-carboniferous limestone; 50 to 72, 1st sandstone; 72 to 92, to 1st limestone; 92 to 166, 2d sandstone, equivalent to the lower Tar Spring sandstone of Breckinridge county; 166 to 214, 2d limestone, increased in thickness. The hills near by contain superior beds to those at the top of section; they are not added because they are so much slipped and disturbed that they cannot be satisfactorily measured.

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bed. Sandstone No. 1 caps the mouth of the branch valley; the limestones beneath are of the cavernous member of the sub-carboniferous. The Sulphur Spring rises in the bed of the main creek.

The strong dip here is nearly south; the direction of the dip at Winchell's mill is northwest; in both instances dipping away from the line of the creeks. The dip at North fork varies from 15° to 35°. On the north side of the creek, near the Sulphur Spring, the dip is less rapid; 5° to 15° toward the southeast; and away from the bend below the Spring, and toward the bend above it.

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Bed of Rough creek.				

Crossing at Eskridge's ferry, the work enters Grayson county.

The first elevation after crossing Rough creek is a steep rocky bluff of 45 to 50 feet; the base and middle of the mass consisting of the beds of limestone No. 2; the upper part being the lower beds of sandstone No. 3.

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Three ledges of limestone, (sub-carb.)	50	------	50	------
Rough creek.				

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	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, conglomerate in lower beds	145	------	427	7
Covered space, showing shales, limestone, and sandstone at the base	134	7	282	7
Sandy shale and limestone	94	------	148	------
Covered space, heavy bed of limestone on top; part of sandstone showing near middle	54	------	54	------
Bed of Rough creek.				

Crossing at Eskridge's ferry, the work enters Grayson county.

The first elevation after crossing Rough creek is a steep rocky bluff of 45 to 50 feet; the base and middle of the mass consisting of the beds of limestone No. 2; the upper part being the lower beds of sandstone No. 3.

Notwithstanding the many reversals of dip the beds are falling toward the southwest; the 3d sandstone being at least 200 feet lower than the equivalent bed at Winchell's mill and McDanielsburg.

The shale beds associated with limestone No. 3 have been found to diminish in thickness from Clover creek eastwardly; they are found to be thickening to the southwest.

From the ferry to the falls of Rough and the Litchfield road the land is

being required to fill the vacancies occasioned by the sunken part of the limestone. The ends of the first beds abut against a perpendicular wall of it; after the cavities are filled, the beds are continuous over the bed previously deposited and the higher parts of the limestone beneath it.

No. 26. *Section of sub-carboniferous limestone and millstone grit beds, north side of Rough creek, at Winchell's mill.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, dark clay shale	21	8	245	8
Limestone	18	------	214	------
Thin bedded sandstone, (probably slipped)	5	------	196	------
Limestone	25	------	191	------
White clay	14	------	166	------
Sandstone, in heavy beds	60	------	152	------
Thick bedded limestone, very few fossils	20	------	92	------
Silicious clay	12	------	72	------
Fine grained sandstone	10	------	60	------
Three ledges of limestone, (sub-carb.)	50	------	50	------
Rough creek.				

From 50 feet to bed of creek, belongs to the cavernous member of the sub-carboniferous limestone; 50 to 72, 1st sandstone; 72 to 92, to 1st limestone; 92 to 166, 2d sandstone, equivalent to the lower Tar Spring sandstone of Breckinridge county; 166 to 214, 2d limestone, increased in thickness. The hills near by contain superior beds to those at the top of section; they are not added because they are so much slipped and disturbed that they cannot be satisfactorily measured.

The waters of the creek being so much swollen that crossing was not possible, the line was retraced to McDanielsburg, and taken up at the forks of the road leading toward the Sulphur Springs, on the North fork of Rough creek. From the forks of the road to the Sulphur Springs the land lies level for two miles, when it rapidly falls off toward the creek, carrying down all the measures, in half a mile, about 100 feet. At the foot of this slope, limestone No. 2 is the surface rock. The rocks between this point and the Springs are broken into faults and waves. Near the Spring one of these waves is cut in section by the creek valley. A small branch flows into the North fork in the trough. The dip is from the main creek up the valley of the branch, which flows on the upturned edges of the rocks, which dip rapidly under its

bed. Sandstone No. 1 caps the mouth of the branch valley; the limestones beneath are of the cavernous member of the sub-carboniferous. The Sulphur Spring rises in the bed of the main creek.

The strong dip here is nearly south; the direction of the dip at Winchell's mill is northwest; in both instances dipping away from the line of the creeks. The dip at North fork varies from 15° to 35°. On the north side of the creek, near the Sulphur Spring, the dip is less rapid; 5° to 15° toward the southeast; and away from the bend below the Spring, and toward the bend above it.

The rocks between Rough creek and Eskridge's ferry are all the beds of the millstone grit; the 5th sandstone capping the "Sand knob" near the farm of Mr. Owens.

From Eskridge's ferry we have the following section—the thickness of the beds determined by barometer:

No. 27. *Section from Eskridge's ferry to top of "Sandstone knob." Horizontal distance, one and a half miles.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, conglomerate in lower beds	145	------	427	7
Covered space, showing shales, limestone, and sandstone at the base	134	7	282	7
Sandy shale and limestone	94	------	148	------
Covered space, heavy bed of limestone on top; part of sandstone showing near middle	54	------	54	------
Bed of Rough creek.				

Crossing at Eskridge's ferry, the work enters Grayson county.

The first elevation after crossing Rough creek is a steep rocky bluff of 45 to 50 feet; the base and middle of the mass consisting of the beds of limestone No. 2; the upper part being the lower beds of sandstone No. 3.

Notwithstanding the many reversals of dip the beds are falling toward the southwest; the 3d sandstone being at least 200 feet lower than the equivalent bed at Winchell's mill and McDanielsburg.

The shale beds associated with limestone No. 3 have been found to diminish in thickness from Clover creek eastwardly; they are found to be thickening to the southwest.

From the ferry to the falls of Rough and the Litchfield road the land is

nearly level; one outline of the shale and the limestone beds of No. 3 being encountered near the forks of the road to McGee's ferry. From this point the dip is south; the surface falling with the dip to the Lichfield road, which is entered at the junction of the beds of limestone No. 2 with sandstone No. 3.

Towards Litchfield the road lies in the valley, and frequently in the bed of Pleasant run, a creek with a rapid fall. The valley of the branch, for a considerable distance, lies on the top part of limestone No. 2. Near the farm of Mr. Jas. R. W. Eskridge the rocks dip rapidly to the southwest; the hill tops on the south being capped by a bed of coal; the hill rising above the branch 217 feet.

No. 28. *Section from Pleasant run to Smith's bank; coal on hill, south of run.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, sandy shale, (?)	30	------	217	10
Iron ore bed, 15 to 25 inches	1	6	187	10
Sandy shale	15	------	186	4
Black bituminous shale	4	------	171	4
Bituminous *coal*	2	------	167	4
Black rash, sometimes bituminous shale	1	4	165	4
Under clay and shale	15	------	165	------
Sandstone, thin beds, (5th sandstone)	20	------	150	------
Steep covered space, top showing coarse sandstone	65	------	137	------
Covered space, limestone and shale (?) beds	72	------	72	------
Pleasant run.				

The coal of this section is the lowest coal seen on the margin of the basin south of Rough creek and north of Green river. It probably lies above all the heavy beds upon the 5th sandstone.

From Pleasant run eastwardly towards Litchfield the road line does not rise above the 4th sandstone.

The aluminous shale associated with limestone No. 3 increases rapidly toward the east, especially the beds forming the upper part of this division. In some localities, the middle part of limestone No. 3 contains Pentremites sulcatus, (?) Rom. This fossil has a short vertical range, and has not been found in any other bed; it is probably a distinguishing and characteristic fossil form of limestone No. 3. It is a rare form, and is found only in certain localities in this bed.

By the line from the Litchfield road to Winchell's mill, Little Clifty is crossed near the Sulphur Springs. The line of Little Clifty presents considerable disturbance, the bed of the creek being on the cavernous member of the sub-carboniferous rocks.

Sandstone No. 1 is quite thin. Immediately below the Spring, an enormous mass of sandstone No. 2 has fallen toward the creek, and forms the bank on the west side of it. The exact arrangement of the rocks was not investigated. On Little Clifty, west of the Spring, the superior rocks are much broken, and in many places are cavernous. Between Little Clifty and Alum Cave fork the beds of sandstone No. 2 and limestone No. 2 are the only beds above the drainage. At the crossing of Cave fork, the upper part of limestone No. 1 is nearly even with the water of the creek; the beds exposed are soft and shaly, and contain great numbers of Productus, Terebratula, and comminuted remains of Crinoidea. The rocks dip to the west and south, frequently interrupted by small faults, by which the rocks are again raised.

The point of intersection with the Winchell's mill and Litchfield road (line D) is on sandstone No. 3. The rocks dip towards the north and northwest from this point nearly to the mill, with occasional waves reversing the dip. The waves are generally small; the effect is quite inconsiderable.

The following section, taken three miles south of Rough creek, at Winchell's mill, will show some of the changes which are presented in the millstone grit beds, and towards the south and southeast:

No. 29.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Bluish-buff sandstone, in thin plates; breaking into rectangular and parallelogramic blocks, (4th sandstone,) fossiliferous; the plates separated by aluminous shale	20	......	243	......
Limestone, buff colored beds	18	......	223	......
Shale bed, seen as red aluminous clay	12	......	205	......
Gray limestone, thin plates	12	......	193	......
Shale, seen as yellowish clay	10	......	181	......
Limestone	18	......	171	......
Shale bed, seen as black clay	8	......	153	......
Thin bedded sandstone, impregnated by coal tar, (3d sandstone)	25	......	145	......
Limestone, oolitic, 38 to 40	40	......	120	......
Sandstone, heavy beds, (2d sandstone)	75	......	75	......
Limestone, thin beds	10	......	......	......
Bed of branch.				

One mile south of the place of section, sandstone No. 3 is well marked with fossil tar, and measures 30 feet thick. The base of the 2d limestone is well seen; the beds are thicker than at any heretofore observed locality.

The summit of the ridge dividing Rough creek and Nolin river, two miles north of Litchfield, has a capping of the wasted beds of the 5th sandstone; some of the localities still preserves the ores equivalent to the bed at the top of Section 28.

South of Litchfield, on the Grayson Springs road, the shale beds associated with limestone No. 3 have increased in thickness. In the following section, one mile northwest of the Springs, the character of this change is set forth:

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of wasted materials of sandstone No. 5	8	------	123	3
Ferruginous sandy shale	20	------	112	3
Yellow aluminous shale, containing iron ore	2	------	92	3
Gray aluminous shale	4	------	90	3
Yellow aluminous shale	5	------	86	3
Blue aluminous shale	3	------	81	3
Yellow aluminous shale	2	------	78	3
Yellow aluminous shale, hard	5	------	76	3
Reddish aluminous shale	5	4	71	3
Covered space, aluminous shale, with fragments of sandstone No. 4	30	4	65	11
Earthy ferruginous limestone	1	5	35	6
Earthy ferruginous limestone, shell bed	1	5	34	1
Yellow aluminous limestone, 4 to 6 inches	6	------	32	8
Red aluminous clay, (Indian red), breaking into angular blocks	10	8	32	2
Yellow clay shales, in place	5	4	21	6
Yellow and blue shale	16	2	16	2
Branch, head of Bear creek.				

The changes in color between the beds of shale are sharply defined; the colors are very bright. The 4th sandstone is represented by a few segregated blocks. Limestone No. 4, if represented at all, is represented by clay shale. On Bear creek, below Grayson Springs, the lower part of limestone No. 3 is seen, represented by 28 feet of limestone, 10 feet of blackish gray shales, above which lies the fossiliferous bed of this locality.

I am not able to fill the hiatus at the base of the above section; the yellow and red shales at the base of the section are not seen at the Grayson Springs.

The section continued downward, by adding the members outcropping at the Springs, will be as follows:

No. 29.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Break at base of section.				
Top of point below Grayson Springs.				
Covered space, aluminous shales	18	------	63	2
Crystalline limestone, remains of Crinoidea	3	6	45	2
Thin bedded limestone, Crinoid beds	1	8	41	8
Aluminous shale, black and gray earth	10	------	40	------
Limestone, in solid masses	30	------	30	------
Top of 3d sandstone.				

Remarkable changes of dip are observed south of Litchfield. The rocks are sometimes disposed in waves which conform to the hills. Descending towards the head of Bear creek the dip is rapid and singular. Near the Springs it is frequently as high as 25°.

From the Springs, eastwardly, to the Millerstown road, the body of sandstone No. 2 is seen on the north side of the creek, rising in bold cliffs. The surface rocks on the south side, near the stream, being the aluminous shale beds of the top of section 29. brought down, probably, by a fault. The top of the ridge, between Bear and Rock creeks, is capped by shale beds or the waste of the 5th sandstone. The hills along the road affords no well exposed section.

The valley of Rock creek is bounded by the 2d sandstone—on the south side of the creek standing in wall-like masses—is here covered with hemlock and laurel.

On the east side of the creek the road ascends the masses of sandstone No. 2, limestone No. 2, sandstone No. 3, and one bed of limestone No. 3, with about 65 feet of clay and marly shales, to the base of the 5th sandstone, when it ascends the divide between the Hunting branch and Rock creek. This ridge is capped for about a mile with a few feet of the base of the 5th sandstone, from 10 to 50 yards wide, resting on the beds equivalent to the shales at top of Section 28. The sandstone here is a coarse conglomerate, containing few impressions of fossil plants.

At the east end of the ridge the rocks have become thinner.

The rocks of section 22 are passed over in descending toward

Millerstown, from sandstone No. 5 to the cavernous member of the sub-carboniferous limestone.

No exposures are seen upon the road, except at the base of limestone No. 3 and the beds of the cavernous member. The top of these beds is buff; having much the character of the buff beds of limestone No. 3. Sandstone and limestone No. 1 are neither of them seen; they are probably absent. The great faults and disturbances beginning at the end of the depositions of the cavernous member, which were so well exposed at Winchell's mill, directed attention particularly to the lower beds of the millstone grit.

To the southwest, down the valley of Nolin river, and along the Hunting branch of Rock creek, we have, on ascending from the river, the following section:

No. 30. *Section at Nolin river, at Millerstown, to the N. W.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Conglomerate sandstone, (5th sandstone.)				
Top of ridge, head of Hunting branch	20	------	300	------
Clay shales—thick near the head of branch, becoming thinner to the west	70	------	280	------
Sandstone No. 3	20	------	210	------
Limestone seen at Hodger's tan-yard	30	------	190	------
Sandstone at top of hill at Millerstown; sandstone No. 1, or Nos. 1 and 2 together, (?)	60	------	160	------
Gray clay shale	7	------	100	------
Limestone, containing Productus	8	------	93	------
Clay shale, soft bed	15	------	85	------
White and gray limestone, sub-carboniferous	70	------	100	------
Nolin river.				

On the head of Hunting branch sandstone No. 4 appears in considerable force, and the shale beds above it are diminished.

The dip lies in the direction of the line of Hunting branch, and the 5th sandstone is brought down to the drainage near "Sugar Camp," below which, for a short distance, the dip is interrupted; finally, at the mouth of Hunting branch, the line of the branch becomes a regular fault; on the south side sandstone No. 4 is the surface rock; on the north, the base of limestone No. 3 forms the line of the creek, standing in its bed at angles, ranging from 20°, 40°, or even as high as 70°; the hill on the north rising a considerable distance by dip alone; and

finally receiving several beds of limestone No. 3, shales, sandstone No. 4, thin shale beds, and sandstone No. 5.

On the south side of the creek the rocks are much broken and bent, presenting the faces of the rocks, which dip south and bring the 5th sandstone nearly to the top of the ridge, half a mile distant. One and a half miles south of the mouth of Hunting branch coal has been opened; it lies in the first valley south of the Hunting branch, having been brought down to the drainage. The rocks with which it is associated are much bent and disturbed, lying in irregular and broken troughs, nearly parallel to the Hunting branch and Nolin river.

The top of the ridge between Rock creek and Nolin river is capped by the 5th sandstone, which dips to the south, bringing the coal bed down to the drainage of the branch, on the south side of the ridge. South of the branch the coal and beds beneath are raised about 50 feet, when the dip is again south for 400 yards; the dip is now changed and rises at the rate of from 5° to 10°, which, in a short distance, brings the inferior beds—*i. e.*, limestone Nos. 3 and 2, with the associated sandstones—into view, high in the hill, half a mile south of the coal opening. The width of the coal bed, as exposed here, is about half a mile, interrupted by one fault near the middle. This locality is in the west end of an outlier, lying between Nolin river and Hunting branch, severed from the coal field, which lies west of it, by Rock creek.

On the north side of Hunting branch of Rock creek, one mile above its mouth, we have the following section:

No. 31. *Section on Hunting branch of Rock creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandy shale, 40 to 60 feet	40	------	209	8
Shale, with thin plates of sandstone	8	------	169	8
Place of Gheslin coal, 2 feet 6 inches.				
Coal rash, 8 inches.				
Irregular bedded sandstone, charged with tar, (conglomerate)	15	------	161	8
Soft sandstone	21	------	146	8
Thick bedded hard sandstone. (at Sand knob, 144 feet)	10	------	125	8
Indurated clay, (slate,) 10 to 12 feet	12	------	115	8
Aluminous shale, generally seen as yellow clay	40	------	103	8
Soft muddy sandstone, (4th sandstone?)	3	------	63	8
Dark lamellar shale, place of coal, (at Horn's old place?)	10	------	60	8
Thin limestone and marlite	2	------	50	8
Aluminous shale	5	4	48	8
Marlite	8	------	43	4
Earthy limestone	2	6	42	8
Aluminous shale	1	8	40	2
Thin bedded limestone	2	6	38	6
Marly shale, broken shells, and Crinoidea	5	------	36	------
Pleurotocrinus remains, bed 1 foot	1	------	31	------
Limestone, large Pentremites sulcatus	3	------	30	------
Limestone, thick bedded	27	------	27	------
Sandstone, bed of Hunting branch, top of 3d sandstone.				

The coal (?) at 60 feet 8 inches has been seen at two localities. The first, at the Horn old farm, 5 miles east of Grayson Springs; the other, in a ravine, three miles N. W. of Millerstown. At both localities, the coal is found under limestone; first, a thin bed of shale, over this about four feet of limestone, upon which rests a sandstone, from 5 to 10 feet thick. The coal at Horn's is 8 inches thick, Pentremites and Retepora Archemides were sought for in the limestone above the coal at both localities, but none were found.

This horizon is probably the equivalent of that of the 10 inch coal reported in diagram No. 4, Vol. 1, Kentucky Reports, as being found on Shot Pouch creek, under Pentremital limestone.

The dividing ridge between Rock creek and the head of Conoloway creek receives the coal above the conglomerate. (See map for northern limit)

The 36 feet of sandstone beneath the coal bed on Section 31, was not recognized on Conoloway and Rock creeks. The 4th sandstone has increased in thickness, and the coal appears to rest on the shale bed at the top of the 4th limestone, which is represented here by a few thin plates, and 6 to 8 feet of marlite. The drains east and north of the

bank cut into the bed beneath the coal, and show a remarkable change to have taken place in these beds. Between the bed here and those seen on Hunting branch, the 4th sandstone has increased in thickness to 10 feet of hard quartzite sandstone. All the beds dip toward Rock creek. On the slope of the hill the measures on top of the ridge are nearly level, or dip very little toward the south.

Crossing the ridge toward Bear creek, several drains are crossed, lying high on the ridge. These drains all cut into the clay shales under the coal bed. The capping of coal measures is from 10 to 50 feet thick.

In the valley of Bear creek, 3 miles south of Grayson Springs, the base of the banded clays of Section 28 is seen at the glade on the road, the lower part exposed:

No. 32. *Section on Brownsville road, three miles south of Grayson Springs.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Surface soil	4	------	39	8
Yellow gray shale, aluminous	2	------	35	8
Dove colored shale, aluminous	2	------	31	8
Purple-red shale, aluminous	3	------	29	8
Blue-red shale, aluminous	1	9	26	8
Yellow gray shale, aluminous	4	------	24	11
Yellow, deeper colored, aluminous	1	8	20	11
Gray shale	2	------	19	3
Yellow shale	1	3	17	3
Gray shaly sandstone	2	------	16	------
Gray shaly sandstone	8	------	14	------
Hard fossiliferous sandstone, (4th sandstone)	6	------	6	------
Branch.				

These banded clays are equivalent to the beds of Section 28; the shades of color distinctly separate the beds by a sharp line; the red band of Section 32 is on the geological horizon of the red band Section 28, at 32 feet 2 inches.

Section 32 is 134 feet below Section 28; difference of level deduced by barometer.

The dividing ridge between Bear and Conoloway creeks, on the line of the Grayson Springs and Brownsville road, is ascended about 4 miles south of the Spring. Where the ridge is ascended by the road, the base

of the 5th sandstone caps the hill. No outcrop of the coal bed was seen on the line north of the head of Saltsman's branch, about 4 miles from Nolin river. The ridge has the measures containing the place of the coal from the forks of the Mammoth Cave and Brownsville road.

The ore beds above the 5th sandstone, which had been opened by the managers of Nolin furnace, are first seen about two miles north of the head of Saltsman's branch. Occasional patches of the measures containing the ores cap the hills nearly to Nolin river. The knolls containing the ores lie on the 5th sandstone, about 50 feet above it, and contain an area from a few rods square to 50 acres and upwards; the beds are easily entered in outcrop. The deepest stripping would probably be 25 feet; the average thickness of the whole ore territory, between Davis' branch and Nolin, would be about 5 feet.

The ore beds are seen frequently north of the head of Dismal creek, and on the high ridges 3 miles north of Green river, on the Brownsville and Litchfield road; surface ores were frequently seen in the road cuts from 40 to 50 feet above the 5th sandstone.

While in the neighborhood of Davis' branch and the furnace, several sections were made of the best outcrops; but it will require very minute surveys satisfactorily to connect the different sections in such a manner as to form an unbroken geological column. The weight of evidence would direct certain connections; but with the facts in my possession, there is so much doubt that I refrain from making any. I will, however, express the opinion I have derived from the facts now in possession.

No. 33. *Section on head of North fork of Dismal creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Top of hill, covered space	26	------	146	4
Sandstone, hard firm blocks	5	4	120	4
Covered space, *laurel horizon*	34	------	115	------
Heavy sandstone	10	------	81	------
Soft shales	2	------	71	------
Ledge of sandstone, partly covered	11	------	69	------
Covered space*	54	------	58	------
Coal in bed of branch, containing several thin beds of black shales and clay	4	------	4	------

* The lower part of this space is black bituminous shale.

Under the coal are coal rash and black earthy shales, from three to six feet thick.

This coal is about thirty-five feet above the limestone first seen beneath it.

The following section is at the coal opened on the east side of Davis' branch, half a mile northeast of the furnace:

No. 34.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Yellow thick bedded sandstone, (5th sandstone)	55	------	168	6
Covered space, terrace	15	------	113	6
Steep covered space, sandstone, (*laurel horizon*)	45	------	98	6
Thin bedded sandy shale, irregular	10	------	53	6
Thin bedded sandy shale, regular	3	------	43	6
Pyritiferous shale	2	------	39	8
Coal. Bituminous	4	------	40	------
Pyritiferous band	2	------	39	8
Coal and shale	6	------	39	6
Coal and clay shale, the latter predominating	2	------	39	1
Pyritiferous *coal*	1	------	37	------
Silicious under clay	3	------	36	------
Sandy shale, 7 to 10 feet	10	------	33	------
Shale and sandstone	21	------	23	------
Limestone	2	------	2	------
Bed of branch.				

One fourth of a mile to the northeast a bed of iron ore has been opened, locally containing great numbers of fossils, principally chambered shells, the forms perfectly preserved as iron ore.

The top covering of the bed, where best seen, for 5 feet was of thin beds, alternately of sandy and aluminous shale; the sandy shale is very soft, composed of coarse sand, charged with fragments of plants. The upper part of the ore bed consists of thin ocherous layers, separated by shale similar to the covering; this bed is very irregular, in thickness from one to three feet. In the lower part of this last bed are deposited, in masses from 10 to 100 pounds, a shelly ore, almost entirely composed of Goniatites Nolinenses, Nautilus ferratus, N. canaliculatus, Orthoceratiti, several species of univalve and bivalve shells, filled and surrounded by ferruginous sand, small fragments of reedy coal, nearly all squarely broken across the length of the plants. Beneath this bed is about ten inches of blocks and irregular formed masses of ore, the whole resting on a thin bedded, coarse sand shales.

The beauty and abundance of fossils, especially the association of shells and plants, render this locality one of no ordinary interest, aside from the value of the ore beds. This bed was not traced to its position in the geological column. It has been located 29 feet above the coal bed of Section 34, (see section page 164, Vol. 1, Kentucky Geological Reports.)

At the head of Saltsman's branch the coal was opened immediately under the 5th sandstone, probably the exact equivalent of the bed at 40 feet at section 34; the sandstone is better exposed here than at any locality visited in this section of the country. It is about 100 feet thick, formed of coarse sand, with some small pebbles on the bedding faces of the rocks. The base of the sandstone is separated from the coal by from five to ten feet of soft materials, principally black bituminous shale. Where opened the coal appears to be of excellent quality, 2 feet 9 inches thick, with 3 to 4 inches of coal rash at the base, on white under clay. The materials associated with the coal at this locality are apparently very different from those in section 34. There can be no doubt, however, that they are part of the same bed.

Beneath the sandstone (5th) which caps the hill near the furnace, we have the following arrangement of the beds:

No. 35.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, sandy shale and sandstone	25	.....	258	6
Sandy shale, or decomposing sandstone	43	2	233	6
Yellow sandstone, soft	21	6	190	4
Carbonaceous band, place of coal	5	4	168	10
Limestone	10	8	163	6
Ore bed?				
Buff limestone, used as flux at furnace	5	4	152	10
Covered space, yellow and reddish clay	37	8	146	6
Shaly limestone, Cellular chert	2	8	108	10
Gray limestone, in thick beds, used in construction of stack	16	8	106	2
Blue aluminous shale, place of Crinoidea beds	5	......	89	6
Buff limestone, with sandy shale	5	4	84	6
Covered space, aluminous shale	16	......	72	9
Limestone, No. 3	43	2	63	2
Sandstone, No. 3	21	......	21	......
Dave's branch.				

South of Nolin river the 5th sandstone increases rapidly in thickness to Bolen creek. On the north side of the river there is also a great

increase of this bed toward Dismal creek; near the mouth of the creek it appears to attain its maximum thickness, becoming much thinner toward Brownsville, where the rocks are represented in the following section:

No. 36. *Section of 5th sandstone and some of the inferior beds, from Green river toward the top of the hills to northwest.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Coarse white and brown sandstone	35	------	272	8
Sandstone, large pebbles	5	------	237	8
Sandstone, small pebbles	5	------	232	8
Coarse yellow sandstone, no pebbles	15	------	227	8
Covered space, gray and black shales, aluminous	20	------	222	8
Covered space, blue shale in cuts	15	------	202	8
Black and dove colored shale	5	------	187	8
Blue muddy shale	12	------	182	8
Aluminous shale, with 14 inches plate of limestone at top.				
Aluminous shale	10	------	165	8
Limestone, 3d limestone	38	------	155	8
Sandstone, (3d limestone,) bed thin on top, thin below	37	8	117	8
Limestone, upper part oolitic	32	4	80	------
Waste of sandstone, 2d limestone	10	8	47	8
Covered space	37	10	37	------
Water, Green river, at ferry.				

One mile north of this section 85 feet of this bed of sandstone is seen in a perpendicular cut, where it has no division.

At no locality south and west of the mouth of Dismal creek has the coal at the base of the 5th sandstone been opened. Several good exposures were seen at the base of the sandstone which exhibited no coal. The place of coal at 168 feet 10 inches (Section 35) was seen as dark, earthy, aluminous shale. Toward the north and west, on the heads of the streams emptying into Bear creek, a bed of coal has been opened, which appears to be the exact equivalent of the Davis' branch coal, Section 34. It is about 28 inches thick, and has been used for smith's work, and is generally approved. The only mining has been performed by stripping the outcrop.

South of the head of Dismal creek, and between Bear creek and Green river, the hills are again capped by the equivalent of the measures containing the ore beds, between Conoloway creek and Davis' branch.

Should the ore beds here prove to be equal in thickness to those on Davis' branch, and north of it, there is ore territory sufficient for sev-

eral furnaces south of Dismal creek, all of which could be sufficiently near Green river to reach navigation at a small expense.

On the road from Brownsville to Cloverport the line of Bear creek is crossed at a fault or slip in the rocks, from the west and northwest side, dipping to the southeast by a constant but wavy dip, for over a mile, bringing the 5th sandstone (?) down to the bed of the creek. On the southeast side of the creek the rocks are apparently raised about 90 feet. In the neighborhood of Little mountain the ore measures again cap the hills.

Satisfactory sections cannot be obtained in the neighborhood of Little mountain; but sufficient may be learned from natural outcrop to show that valuable iron ores may be obtained in vast abundance, over a large district lying between Bear creek and along the dividing ridge between Green river and the waters of Rough creek.

The following section from Little mountain, near the farm of Mr. Robinson, appears to contain beds not found further west; they probably thin out to the west and southwest:

No. 37. *Section at Little mountain.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Coarse sandstone, no pebbles	8	------	192	------
Fine grained sandstone	7	------	184	------
Iron ore (?) bed	7	(?)	177	------
Shales, mostly covered	36	------	170	------
Block ore, 2 to 4 feet	4	------	134	------
Shales, mostly covered	55	------	130	------
Shale, bottom carbonaceous	21	------	75	------
Segregations of carbonate of iron	4	------	54	------
Black bituminous shale, 6 to 11 feet	8	------	50	------
Coal, 12 to 30 inches, equivalent to Nelson and Smith banks	2	------	42	------
Under clay and coal rash	40	------	40	------
Sandy shale, yellow in exposed situations	28	------	36	------
Gray mud shale	4	------	8	------
Dark gray shale, 2 to 6 feet	4	------	4	------
The fifth sandstone.				

The top of the 5th sandstone is frequently exposed in the deep drains.

In several localities the shale at 75 feet in the above section, lying immediately above the ore bed, is marked by fossil plants and small fragments of reedy coal.

For several miles toward the northwest the line of the road has cut into this sandstone, which, if followed, will soon lead to a cut exposing the ore bed beneath it.

At the intersection of the Litchfield and Morgantown with the Brownsville and Cloverport road Mr. William Nelson has opened and worked a coal bed at 42 feet, in Section 37.

The following is the arrangement of the materials of the measures at Mr. Nelson's coal bank:

No. 38.

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Surface soil, broken sandy shale, with a few loose blocks of quartzose sandstone	5	------	14	9
Black earthy shale	4	------	9	9
Black bituminous shale	2	------	5	9
Coal	1	6	3	9
Earthy band	------	3	2	3
Coal	2	------	2	------
Under clay, thickness not seen.				

No remains of the ore bed were seen near the Nelson "bank;" it is probable that the ore is separated by a greater interval than that given in Section 37.

Between the road above referred to and the crossing of Short creek the coal measures cap the hills in diminished quantities. The ridge south of the crossing of Caney creek has, probably, the greatest thickness.

Near Camp No. 17 the shales and Nelson coal (?) are seen in a deep valley, the hill to the east and west is capped by a sandstone, the equivalent of the Little mountain sandstone.

At the crossing of Caney creek, near the farm of Mr. George House, the rocks dip to the south and southwest at an angle of 5° or 6°. The bed of the creek at the crossing is the upper part of the limestone of No. 3, above which we have the following section:

No. 39. *Section at the crossing of Caney creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches
Coarse sandstone, top of hill, (5th sandstone)	15	------	140	10
Yellow or buff limestone and shale	33	------	125	10
Yellow silicious mudstone, (4th sandstone)	16	4	92	10
Drab-gray aluminous shale	26	------	75	2
Buff limestone	------	4	49	2
Blue-gray shale	16	6	48	10
Blue-gray shale	26	------	32	4
Chert beds	5	4	6	4
Dark shale	1	------	1	------
Limestone, bed of Caney creek.				

On Bennet's creek, 2 miles north, the 4th sandstone is seen in great perfection; it lies in blocks from 1 to 8 inches thick, breaking at right angles and perpendicularly to the bed faces of the rocks; many of the different layers are fossiliferous. It is a drab gray quartzose sandstone; maintaining its peculiar lithological character over a large district of country; the bed is, however, frequently interrupted and wanting. It is occasionally seen in every part of the country, on the margin of the coal measures, from Grayson to Christian counties.

The dividing ridge between Bennet's creek and Short creek has been denuded of all, or nearly all, of the coal measures. The road lies in many places on limestone, at Section 39.

On the north side of the valley of Lost creek the sub-carboniferous rocks are brought above the drainage; the dip from this axis of disturbance is toward the north and northwest from 25° to 30°, diminishing the angle of the dip toward the north. The upturned edges of sandstone No. 2 and limestone No. 2 form the first hill, which, on its western slope, is capped by sandstone No. 3, which underruns limestone No. 3, at Mr. Tilford's—the hill north of his house being composed of the limestone and shales of No. 3, capped by the waste of sandy shales at the base of the 5th sandstone. The dip has changed at Mr. Tilford's, and lies toward the southwest.

From the hill near Tilford's to the falls of Rough creek the surface falls about 310 feet. The base of the 5th sandstone is reached on only one hill between the two points. Great masses are seen on the ridge south of the road; probably 65 feet of it caps the hills. At the falls

of Rough creek, the measures seen at Mr. Tilford's, and frequently between the two points high on the hills, form the surface rocks in the bed of the creek; much changed, however, in lithological character. The exact counterpart of limestone No. 3 is seen below the dam at the mill. It has not been met in any part of the margin of the coal field.

No. 40. *Section at the Falls of Rough creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches
Surface soil	3	------	22	8
Aluminous shale	2	------	19	8
Black aluminous shale, 8 to 14 inches, non-fossiliferous	------	8	17	8
Thin flags, limestone	6	3	17	------
Marly shale, Spirifer and Productus	1	8	16	8
Hard sandy porous bed, containing Agassizocrinus; no other fossils observed	1	------	14	10
Carbonaceous aluminous shale, non-fossiliferous	3	------	13	10
Hard limestone, containing Crinoidea	1	------	10	10
Calcareous shaly bed, containing Bryazoa and Crinoidea; Pentremites rare	3	------	9	10
Calcareous shale, Bryazoa bed	2	------	6	10
Silicious calcareous bed, yellow Crinoidea and Pentremites	1	6	4	10
Limestone, gray, Crinoidea and Pentremites	1	6	3	4
Yellow silicious bed, segregated chert, containing Pentremites	1	10	1	10
Thick bedded limestone, bed of creek.				

The water of the creek has washed the soft shaly beds, undermining the hard bed from 6 to 8 feet, thus giving a perfect exposure of the character of the several beds.

Above the bed of above section the hill on the north side of the creek rises from 200 to 275 feet, formed of the shales and limestone (No. 3), of sandstone No. 4, and limestone No. 4, all capped near the creek by the base of the 5th sandstone. The road from the falls of Rough creek to Cloverport lies nearly with the line of strike, the branches and creeks indenting the margin of the coal field, leaving narrow bands of the coal measures upon the ridges between them. The ore beds near the top of the 5th sandstone are seen occasionally on this line.

At Mr. Wm. H. Howard's the ore beds are cut by the wear of the road. The ore is about 2 feet 6 inches thick, apparently of good quality. It lies in blocks, in a regular bed.

The shales of the 2d limestone are thicker here than farther east; the beds of limestone are also more compact and in thicker ledges, while the whole mass of the bed is less thick.

The Belerophon bed at 296 feet 2 inches (section 22) is recognizable in all the valleys between the falls of Rough and the Owensboro road, 5 miles south of Cloverport. The measures on the line of the road to Cloverport are all beneath the sandstone at 420 feet 2 inches, Section 22.

The following line crosses part of Breckinridge, the corner of Hancock, into Ohio, and closes on the last line on Bennet's creek. (See map.)

The river hills to the southwest of Cloverport are capped by the base of 5th sandstone. Below the sandstone the 4th limestone is a thin bed, 6 to 8 feet thick, containing Bryazoa. The shales of the 3d limestone are marked by three yellow or buff beds, separated by from 8 to 10 feet of gray or dove colored shale. The Owensboro road was crossed near Mr. Newton's farm. The ridge dividing Clover creek and the head waters of Panther creek receives a few feet of the shales under the "Breckinridge coal."

The ore bed was seen in a few places on the line; it is sandy, and thinner than farther to the south, east, and southeast and south.

On reaching the head of Panther creek the rocks are seen dipping to the south and southwest, the 4th limestone being the surface rock in the bed of the branches. The hills rise from 80 to 150 feet high above the drainage, and are made up of the bed of the 4th sandstone, shales, 5th sandstone, and a thin capping of coal measures above it. These patches are outliers of small area, and are not known to contain a workable coal.

On the Sugar Camp branch of Panther, about 2½ miles south of the dividing ridge, the coal measures are brought to the drainage.

Between Sugar Camp creek and Rough creek, at Hine's mill, the hills contain the measures of the Hawesville section up to the Lewisport coal. The limestone of the coal measures beneath the Lewisport coal bed forms the bed of Adam's fork of Rough creek for a considerable distance, the rocks dipping at the same rate as the fall of the creek.

Near Fordsville iron ore beds are exposed in natural outcrop in the road; the ore is sandy; it lies in sandy shale, 25 feet above limestone, which is probably the equivalent of the limestone under the Lewisport coal of Hancock county.

Between Fordsville and Hines' mill the hills are low; occasionally

fragments of coal may be found in the branches; none of the coal beds of this part of the county have been opened. On the north side of Rough creek the country, for a considerable distance, is flat, and overflowed by the creek during its floods. On the south side of the creek the lands are rather higher, but quite flat; the low ridge on the northeast side of the road being soft, sandy shales. About a mile south of Hines' mill a bold sulphur spring rises in the flat. One quarter of a mile south of the spring the rocks are found disturbed, and dipping to the northwest; the fault or disturbance having brought up the limestones of the millstone grit. High hills of soft measures lie toward the east and southeast, containing thin coal beds. The 5th sandstone has become soft, and much thinner than it is eastwardly; no pebbles were seen in any part of this bed between Caney creek and Green river. The lower part of the bed is represented by thin, ash-colored, sandy shales; the 4th limestone has an earthy fracture, and may, possibly, possess hydraulic cement properties. The drains and creeks frequently cut through the coal measures between Hines' mill and Caneyville. On the Caneyville road toward Litchfield the hills are capped by about 80 feet of coal measures, containing the coal measures and ore bed in Section 28 at 187 feet.

The ore bed is seen denuded near Caneyville, on the property of S. W. Bond. An opening has recently been made in the bed, which is five feet thick, consisting of blocks of ore and ocherous earth.

The cuts made by the branches and creeks are quite favorable for sections east and north of Caneyville as far as Bennet's creek. The ore bed exposed is not so thick as the equivalent bed seen west of Caneyville. It is, probably, not so thick as it is to the south and east.

The 5th sandstone between Caneyville and Bennet's creek is quite thin. It is represented by about 25 feet of soft sandstone, in thick beds, and about 55 feet of sandy shale, beneath which the 4th limestone has a thickness of about 25 feet—the thickest mass of this bed seen. Two miles to the north, at Mr. Howe's, (see Section No. 39,) it is entirely absent, its place being occupied by aluminous shale.

The only coal opened near the line of our work was that opened by Mr. Wm. Miller, southeast of the road, 1½ miles from Caneyville. The opening is made on the south side of a ravine. The coal is covered by 18 feet of sandstone and 5 feet of black bituminous shale, which is

sometimes changed to gray sandy shale. The coal, where seen, measures 20 to 22 inches; it lies on 3 to 4 inches of coal rash, under clay, and sandy shale; 18 feet to limestone in bed of drain. On the north side of the drain the limestone in the bed of the creek on the south side is lifted about 22 feet above the coal, the slip being 30 feet. The covering above the coal is about 45 feet thick.

From Caneyville to Morgantown the hills rise higher above the drainage, and are composed of vast beds of sandy and aluminous shale. At Dog creek the cuts reach the base of the 5th sandstone. South of the creek the land becomes level, with occasional knolls of the softer shale beds above the 5th sandstone, which sometimes rise from 80 to 100 feet above the general level of the country.

The head of Welch's creek cuts through the shale bed and into the 5th sandstone. From Welch's creek to Green river the road rises to the soft beds above the sandstone. One mile north of Green river the Yellow rock over the Roberts coal (Muddy river) is first recognized.

At Green river the 5th sandstone lies even with the pool. On the south side of the river the rocks rise in the direction of Morgantown, and again dip rapidly toward the valley of Renfro's creek and Woodberry. At the top of the ridge, east of the mouth of Big Barren river, the pebbles and small patches of the 5th sandstone are occasionally seen.

Returning to Morgantown and taking the line of the road to Russellville, the land soon becomes level or gently undulating; the valley of Renfro's creek is wide and flat; evidently underlaid, for a great part, by the rocks of the section taken at the coal bank opened by Mr. Moses Shearer, one and a half mile to the southwest of Morgantown.

No. 47. *Section of coal opened by Mr. Moses Shearer, near Morgantown.*

	Thickness.		Elevation.	
	Feet	Inches.	Feet.	Inches.
Top of hill sandstone	10	------	86	9
Covered space, aluminous shale	10	------	76	9
Limestone and aluminous shale	4	------	66	9
Aluminous clay and shale	18	------	62	9
Aluminous shale, segregations of limestone and marly shale, fossiliferous	10	------	44	9
Carbonaceous clay, pieces of coal in some localities	1	6	34	9
Drab aluminous shale	10	------	33	3
Black bituminous shale	------	8	23	3
Coal	3	7	22	7
Under clay, dark micaceous	5	------	19	------
Covered space	14	------	14	------
Bottom of drain.				

To the southwest from the Shearer coal locality, better known as the "Limestone hills," two and a half miles, the margin of the coal measures are reached, on the dividing ridge between Renfro's and Sandy creeks.

The valleys of Sandy, Big Muddy creek, and Muddy river cut into the millstone grit beds nearly to the mouth of all these water courses.

The coal measures are again seen on the dividing ridge between Big Muddy and Muddy river, north of McCoy's mill.

The Shearer coal has been opened and worked at several localities on this ridge. It is very unequal in thickness, varying from eighteen inches to three and a half feet. The termination of the coal to the southwest, between Muddy river and Big Muddy creek, is near the forks of the Elkton and Russellville road.

The work was extended toward Elkton, in the expectation of finding outliers of coal measures, to Haroldsville. At Rock Spring meeting-house, 45 feet of the 5th sandstone is found. It is here a coarse conglomerate, resting on the 4th limestone, which has the appearance of being water-worn previous to the deposition of the 5th sandstone.

The line was continued to within 8 miles of Russellville, when the 2d limestone was reached. It is oolitic, and greatly increased in volume, about 60 feet being in sight, and the bottom concealed below the drainage.

From the last point toward Greenville, by the Russellville and Green-

ville road, the rocks are found nearly level, or dipping slightly to the northeast. The country is level and rich; the soil being mostly composed of the waste of the 4th limestone, and the shades of the 3d limestone; the 4th sandstone is absent on the line of this road, or it is not recognizable.

The 5th sandstone is reached at the head of the Little Rawhide creek, a branch of Wolf Lick creek. It is a coarse conglomerate, 40 to 55 feet thick; the upper part of the mass is coarse, hard sandstone.

The dip of the rocks is to the southeast on the Wolf Lick side of the ridge and to the northwest, and occasionally the dip is seen lying toward the southwest.

Several patches or outliers of coal measures are seen on the hills between the northern branches of Muddy river and Clifty creek, rarely over sixty or seventy feet thick, above the 5th sandstone. One outcrop of ore was observed between the points above alluded to.

Near the crossing of Clifty creek the 5th sandstone is seen in heavy masses, 25 to 30 feet thick. North of Clifty the coal measures are reached at the Dug hill, half a mile southeast of the Rochester and Elkton road, where the following section is seen in the road:

No. 42. *Section at Dug hill, Muhlenburg county.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches
Sandy shale, 90 to 110 feet	90	------	169	6
Sandstone	11	------	79	6
Aluminous shale	38	------	68	6
Iron ore	------	6	30	6
Sandy shale	30	------	30	------
Top of 5th sandstone.				

The whole mass of sandstone at the base of the above section is about 80 feet.

From the intersection of the Russellville and Greenville with the Elkton and Rochester roads, to the narrows, the road lies on the upper part of the section above; near the narrows the road suddenly descends to the 5th sandstone—*i. e.*, the margin of the coal measures.

The 5th sandstone dips to both sides of the road from the ridge, (narrows,) which is probably an anticlinal wave; the synclinals on either

side being in the beds of Clifty creek, on the east and eastern branches of Pond river, on the west side of the ridge.

South of the narrows the 4th limestone and the 4th sandstone are dipping rapidly toward the northeast, and are raised a considerable distance above the horizontal position of the 5th sandstone at the narrows.

The narrow part of the ridge is about 60 yards wide, being, in fact, only a huge mass of the 5th sandstone, 80 feet thick, which is little else than a loose mass of quartz pebbles about the size of marbles, through which the water percolates. Being arrested by the clay shales at the base of the sandstone, it breaks out in bold springs on the east side of the ridge, which is doubtless the direction of the greatest dip of this locality.

About one mile south of the narrows the road has descended to the 3d sandstone, and the rocks are quite level, or are dipping gently to the southwest with the line of the branches to Pond river. The coal measures lying between the head of Pond river and Clifty are only a few feet thick, (80 to 110 feet,) from one to two miles wide, deeply indented by the streams, especially on the west or Pond river side of the ridge. The work having been extended from the narrows to the intersection of the "Old Highland lick" and Elkton road—sandstone No. 3 forming the surface rock—the Lick road was taken, and the line run to Bennet's mill, on Pond river.

On descending the first hill limestone No. 2 is reached, which continues to be the surface rock for about three miles; the direction of the road being to the northwest. Near the East fork of Pond river the dip becomes quite rapid, and brings down the mass of limestone No. 3, with its associated shale beds, to the East fork, in a few places covered by fallen masses of the pebbly part of the 5th sandstone. West of the East fork the dip is to the northeast, meeting the dip from the opposite direction near or at the line of the river.

The 3d sandstone has become quite yellow, and in the valley of the East fork forms the surface rock on the west side of the stream. The north side of the road is skirted by a low range of hills, composed of the 3d and 4th limestones, with a thin bed of the 4th sandstone; the whole mass 94 to 110 feet thick. Between the East fork and Bennet's mill, on West fork of Pond river, the ridge is composed of the millstone grit bed, from the 3d sandstone to the coal measures, including, on the

top of the most elevated points, from 15 to 30 feet of the soft bed above the 5th sandstone; the members, from base to top of the hill, being probably less than 200 feet thick.

The hills are broken; the dip irregular and wavy, falling from the summit of the hills to the streams on the east and west side; the height of the divide by barometer being 426 feet; 226 feet being due to the dip. The 3d sandstone is the surface rock in the valley of both the East and West forks when intersected by this line.

Line A extends from Bennet's mill to Petersburg, by the way of White Plains. On this line, which lies outside of the coal measures nearly its whole length, it was observed that the clay shales, associated with limestone beds Nos. 2, 3, and 4, are replaced, either in part or altogether, by sandy or micaceous shale. The mass of the 3d sandstone is also much expanded near Front Hill post-office; being there about 65 feet thick.

Plates and segregated masses of chert are associated with the 3d and 4th limestones. The higher beds are strewed with blocks of sandstone No. 4, and pebbles derived from sandstone No. 5.

The ridge dividing the valley of McFarland's creek and West fork of Pond river is capped by heavy masses of the 5th sandstone, (coarse conglomerate.) From the top of this ridge toward the northwest the dip is rapid, bringing the 5th sandstone to the valley. In about one and a half miles the dip is then interrupted and increased from 15° to 20°. This rate of the dip soon brings the 5th sandstone under the drainage, when it is brought up again by a slip of from 75 to 80 feet, and again dips below the drainage, to be again brought up by a similar fault—this arrangement being repeated four several times, gradually diminishing, and finally, the sandstone disappears under the soft shale bed of coal measures, to be again brought up two and a half miles distant, on the Madisonville and Hopkinsville road, at Mr. Brazier's, when the dip is from 8° to 15° to the northeast, marking the western margin of the synclinal fold.

At 254 north a bed of coal, one foot thick, is seen in outcrop, with under clay 6 inches beneath the coal; there is probably 65 to 80 feet of sandy shale, with one or two interrupted beds of sandstone. The measures from the conglomerate (5th S. S.) to the coal were not satisfactorily made out; the bed being so frequently slipped in this locality; it is not

improbable that some of them have been duplicated in the measurement between the 5th sandstone and coal.

Southwardly from Mr. Brazier's, at the margin of the coal field, toward Hopkinsville, the conglomerate beds are about 80 feet thick, resting on sandy shale. The measures lie in waves from three to four miles wide, with a gentle dip from ½° to 2½°. The synclinal fold is here first encountered. Its apparent depth is somewhat increased by denudation, which reaches the top of the 2d limestone. The western margin of the first anticlinal shows sandstone No. 3 near its base, dipping westwardly at 3½° to 4°. The banded shale beds and 4th sandstone are occasionally seen nearly to the sub-carboniferous limestone, which appears to abut abruptly against the shales above the 4th sandstone. The 1st and 2d sandstones are not seen east of the margin of the coal measures, in the edge of Christian county; nor is the 3d sandstone seen east of the 2d synclinal fold. The 4th sandstone and the banded shales are recognizable nearly to the margin of the sub-carboniferous limestone, 4 miles west of Hopkinsville. The indications are that the beds of millstone grit below the 3d sandstone have thinned out toward the east; or else, that they have been carried away before the deposition of the 2d limestone. The 4th sandstone, although very small, is so strongly marked by its distinguishing characteristics, that it is a reliable horizon whenever it is present. It is the only sandstone bed of the millstone grit beds now known containing fossil shells. It may be known by its lithological character alone.

The lines in Hopkins county were taken up at Clark's mill on Pond river, and carried to Greenville, connecting the work previously done in Hopkins and Muhlenburg counties with the survey of the margin of the coal field made this summer.

The work taken up on Pond river begins at a point high in the coal measures. The clear coal of the Hunting branch of Clark's creek is seen in outcrop near the mill, on the northeast side of the river, (see section, page 136, Vol. 1, Kentucky Geological Reports.) The coal dips rapidly about 4½° to northeast, away from the river. The beds forming the hill above the coal consist of from 50 to 60 feet of sandy and aluminous shale, 30 to 35, space covered, the whole capped by a very coarse-grained loose-textured sandstone. The waste of the beds forming the covering of the coal beds forms a warm productive soil,

and distinguishes the country between Pond river. At Mr. John Oats', six miles southwest of Greenville, two wells have been dug by Mr. Oats, both of which reach a bed of coal said to be five feet thick. This is probably the equivalent of the upper bed at Clark's mill. The measures change between Mr. Oats' and Greenville. The reason of the change is not apparent on the line. The shales are evidently thicker; the coarse sandstone has disappeared; the soil and timber are changed. The measures between Pond river and Mr. Oats' are again recognized near Pond creek, five miles south of Greenville. It is highly probable that the measures lying north of a line from Mr. John Oats' to Pond creek are higher than in the hills above the coal near Pond river; and that they correspond to the shales above the equivalent of the Anvil Rock at Providence.

At Mr. G. Leigh's, on the southeast side of Pond creek, a fault was encountered on the road. The rocks on the line dip to the northeast, at an angle from 45 to 50°.

The millstone grit beds are raised high in the hills, and extend to Clark's mill, on Clifty creek, as surface rocks. The dip is quite inconstant, varying both in quantity and direction.

The line between Clifty creek and Muddy river lies almost directly on the margin of the most southwardly outcrop of the 5th sandstone, and about two and one half miles south of the Roberts coal banks, on Muddy river.

On the northwest side of Muddy river the 5th sandstone is a coarse conglomerate. The masses of this rock lying near the river occupy a lower level than the equivalent bed toward the divide between the two streams. The bed is well exposed near the center of the divide, where it is a coarse sandstone without pebbles. On Clifty, 2½ miles to the northwest, it is strangely marked by pebbles, some of which are of large size, from 1½ to 2 inches in diameter.

To the southeast of Muddy river, the line was connected with the Rochester and Russellville road, and carried toward Rochester, (see map.) The hills toward Rochester are millstone grit. Deer Lick cuts into the 3d limestone. The 4th limestone and the 4th sandstone are both seen on the south side of Deer Lick. On the northeast side of Deer Lick creek the line rises a hill, the whole mass of which, from top to bottom, is composed of coarse sandstone (5th S. S.) without pebbles.

The country above this sandstone is nearly a plain, on which rounded knolls of coal measures are seen from 80 to 150 feet high; these measures continue to the Russellville and Morgantown road with the road to Rochester. From this point to Morgantown the line crosses a synclinal, the coal measures extending nearly to Morgantown.

Southwest of Morgantown the coal measures of Renfro's creek are no doubt connected with the equivalent beds lying in the valley of Big Muddy and Hickory Camp creeks.

The dividing ridge between Big Muddy and Renfro's creek, at the "Sand Hill," receives the coal measures as high as the equivalent of the sandstone at the top of the Little Mountain section of Edmonson county, (Sec. No. 37.) The difference of level from Big Muddy to top of the "Sand Hill" being 163 feet.

Between Morgantown and Woodbury the country is level and gently rolling; the creek valleys wide. At Morgantown the rocks dip to the southeast, bringing the measures of the hill below the valley of Renfro's creek in a short distance. The shale beds above the Morgantown sandstone being the surface material nearly to the mouth of Big Barren river. Sandstone 37 feet thick, in section, page 161, Vol. 1, Kentucky Geological Reports, is no doubt the equivalent of the sandstone at the top of the hill at Morgantown.

On the east side of Big Barren, as before stated, the conglomerate caps the hill-tops 175 feet above the river; the direction of dip was not satisfactorily observed. Toward the east, on the Glasgow road to Mr. J. M. Young's farm, 3 miles from the mouth of Big Barren, the hills do not contain coal measures. The well at Mr. Young's being sunk into the sandy micaceous shales at the base of the 5th sandstone. Southeastwardly from Mr. Young's, the country rises by a gentle slope about 100 feet in two miles; the measures rise with the hill, and only a few feet of the masses of the 5th sandstone, 30 feet above the horizon at Mr. Young's, cap the highest point of the ridge.

Descending the ridge toward the south appeared considerable masses of brecciated limestone, composed of limestone No. 4 (?), cemented by a silicious paste, containing small fragments of chert. The breccia occupies the horizon of the 4th limestone in a bed of aluminous shale. At the base of the shale the rocks are nearly level. The valleys are expanded, and, for several miles, the road lies either on the 3d lime-

stone or the 3d sandstone. Five miles to the northwest of Bowling-Green the road descends to the cavernous limestone. The hill bounding the valley on the north is capped by sandstone No. 2. The south side of the valley is partially bounded by isolated hills, which are capped by the 2d sandstone. The first sandstone was not recognized in Warren county. The base of the sandstone rests on Dichocrinus beds, doubtless the equivalent of the beds of Grayson county, 60 feet below the base of the 1st sandstone.

The general trend of the southern margin of the 2d sandstone is nearly east and west; no roads are made parallel to and south of Green river, north of the sub-carboniferous limestone. Between the lines of the Bowling-Green and the Woodbury, and the Bowling-Green and Brownstown roads, Line R was carried up the valley above referred to, to the Bowling-Green and Brownsville road, and by the last road to Brownsville.

After taking the road toward Brownsville, in two miles we reached the base of sandstone No. 2. The top of the ridge or table land is capped by about 65 feet of sandstone. On ascending the hill it turns toward the coast, and for two miles lies nearly on the strike. At 304, Line R, the road reaches a disturbed territory; the rocks dip to the northeast, at from 5° to 35°. Here the road makes a sudden bend toward the north, and runs over the upturned edges of the 3d sandstone for half a mile, to the hill on the south side of Alexander creek; here the 3d limestone is first seen on this road, unless the limestone seen at the last bend of the road be this bed. From Alexander creek to Chameleon Springs the rocks are disturbed. The greatest disturbance appears to be east of the road.

From the Springs to Brownsville the road lies on the beds below the 5th sandstone; rarely cutting below the 3d, even in the deepest valleys; reaching the 5th sandstone only once or twice. On this line, from the mouth of Barren river to Brownsville, there are only one or two small patches of coal measures above the 5th sandstone. No indications of workable beds were seen or heard of near the line. Between the line and Green river a coal is said to exist in good workable beds, probably the coal equivalent to that at Nolin furnace, Edmonson county. It was desirable that the territory near Green river should have been examined for the iron ore equivalent to the Nolin beds, but the

difficulties of the country were such that with one camp arrangement we were not able to travel it. It is known that outliers of the coal measures exist on the south side of Green river, east of the mouth of Big Barren. Of their value and extent nothing is certainly known. The ore bed found on the Rudy's and Sunfish creeks may possibly extend with the measures across the river; should they do so, and have the thickness and quality of the beds north of the river, their vicinity to navigation would render these ores of great value, especially as furnace rock, limestone, and wood are here in the immediate vicinity of the ores.

Having closed the line from Morgantown, on the lines formerly carried to Brownsville, the work was carried from the latter place to the Mammoth Cave; when Green river was crossed, and the line carried to Millerstown, through Edmonson and Hart counties.

From the forks of the Brownsville road to Bowling-Green and Munfordsville, by the road to the latter place to the Mammoth Cave, the 4th limestone and the 4th sandstone are absent; the shale beds of the third limestones are very thick, and form with the 3d limestone the surface rock for several miles.

Near the "Turn-hole," the 2d limestone and 2d sandstone are surface rocks. Between the "Turn-hole" and the cave the 2d sandstone is the surface rock for two and a half miles, when the surface becomes broken by deep sink holes for three quarters of a mile.

The flat table land near the cave lies on a mass of the 2d sandstone, which has a slight dip to the southeast. The Cave House is situated about 285 feet above Green river. The cavernous limestone is cut by the valley of Green river 213 feet.

The hills on the north side of the river are capped by the 2d sandstone which lies lower than the same bed on the south side of the river. About four miles north of the river, at Mr. P. P. Pace's farm, the road ascends the bed of the 5th sandstone, which is a coarse conglomerate, lying, by barometer, 329 feet above Green river.

For several miles to the northeast, the 5th sandstone is capped by occasional knolls of coal measures from 50 to 75 feet higher.

At the head of Belew's creek and Dog creek, the coal measures rise sufficiently high to receive the ore beds. It is not known that they exist here, nor can the question be answered except by digging.

After crossing Dog creek, the measures do not rise high enough

above the 5th sandstone to receive the ore beds. At the crossing of the Bacon creek the cavernous beds of the sub-carboniferous limestone are reached; these beds extend to Wheeler's mill, on Nolin river. As soon as the river is crossed the beds of the millstone grit are reached, which are the surface rocks nearly to Millerstown.

Crossing the river at Millerstown, the cavernous member of the sub-carboniferous beds form the surface rocks, with occasional patches of sandstone on the highest knolls, probably the waste of the 2d sandstone, which is seen in bold outliers toward the west. It forms the first sandstone hill west of Stephensburg. These patches of sandstone occupy quite a limited territory, the last seen are about six miles northeast of Millerstown.

The accompanying map is constructed from the lines actually run, from which it will be seen that a large portion of the margin of the coal measures are only approximately determined, as only that part absolutely determined is marked by solid lines, and all parts not so determined indicated by dotted lines.

The interior of polygons made, in which ore beds are known to exist, must be surveyed in detail to give an approximate determination of the extent and value.

The margin of the coal field extending from Clover creek, through Grayson, Edmonson, Butler, and part of Warren, will no doubt afford a territory rich in iron beds. The marginal coal beds are generally too thin to be of great value. In many localities they are found in sufficient thickness to be profitably wrought. The broad territory on the eastern margin of the coal field, which is thinly overlaid with the lowest coal measures, will give greater facility in reaching the iron ores, which have been sufficiently stripped by denudation to render them accessible at a moderate cost.

The ores, coal, rocks, soils, &c., collected during the surveys of this season, have been forwarded to the Geological Laboratory. Many of them probably cannot be reached by the chemist in time for analysis during the present season.

During the last two years, our parties have been treated with great kindness, and have received every facility required in the prosecution of the survey. To all those to whom I have been indebted, I take this public method of acknowledging my obligations. They have my thanks.

SIDNEY S. LYON, *Assistant Geologist.*

Since the foregoing part of this chapter was written, the work of the base line has been carried forward, and the work terminated on Tug river, which forms the eastern boundary of the State.

It will be necessary to add a brief description of that part lying between the termination of the work of last year and the end of the line.

The total length of the base line is three hundred and six miles, eighteen hundred and thirty-two feet. It lies in the following counties: Union, Henderson, McLean, Daviess, Hancock, Breckinridge, Hardin, Nelson, Washington, Mercer, Garrard, Jessamine, Madison, Estill, Powell, Owsley, Morgan, Breathitt, Floyd, Johnson, Lawrence, and Pike. Twenty-two counties are intersected by it. Nine of the counties enumerated are in the eastern coal field, either wholly or in part; the first five being in the western coal field.

The work on the line this year has been in the counties of Johnson, Floyd, Lawrence, and Pike. The country traversed in these counties is rough, rising into narrow, steep ridges, which ascend above the drainage of the country from two to six hundred and sixty-one feet, and is usually divided into terraces, or benches, caused by the unequal decay of the hard and soft beds composing the coal measures.

The soil in the valleys is generally sandy. The sides of the hills are covered by small pieces of shale or blocks of coarse sandstone.

The farms are generally quite small, lying in the narrow valleys extending along the streams; sometimes embracing the sloping land at the foot of the hills.

The valley land is estimated at about ten dollars per acre, that of the hills at from fifty cents to one dollar.

Procuring and rafting saw logs is extensively carried on in many places. Wagon roads are almost unknown, yet the country could be traversed in many directions by roads which could be made at a small cost.

Salt making has been carried on for a short time at Warfield, on Tug river, from which point the salt is distributed either by pack horses through the country, or in canoes on the river.

The rocky masses lying above the drainage, from Jenney's creek eastwardly, consist of the beds lying above the Licking shales. Some few cuts are made by the streams, from thirty to fifty feet below the

coal, which has been variously designated as the Adamsville coal, Jackson Rice coal, &c.

At the last crossing of Jenney's creek, on the 279th mile, the coal bed above referred to lies a few feet below the bed of the creek. It has been traced up the creek about two miles. Sometimes it is above the creek bed, and sometimes below it. This bed here dips with the line of the stream, but it is irregular and full of waves. The bed of coal is also quite irregular. It is sometimes seen as one bed; at other places near by it is divided into two beds, the separation being from half an inch to four feet thick. The upper part of the bed affords as much as two feet thick of workable coal; the lower division being from one foot to two and a half feet thick.

On the east side of Jenney's creek, the hill rises above the creek 661 feet, (barometer,) and is divided by the hard and soft measures into six terraces, or benches, composed alternately of sandstone and shale beds, the capping mass of the hill being a heavy sandstone, the lower part of which is locally a conglomerate, thickly charged with water-worn white quartz pebbles.

The measures above enumerated are found in part in every hill between Jenney's creek and Tug river—no hill ever rising geologically higher than the great sandstone which caps the hill at Jenney's creek.

The coal beds which are found high in these measures (to be hereafter noted) do not extend to the west of Big Sandy river on this line as good workable beds. The place of the beds found in some localities west of Big Sandy river is indicated by a streak of carbonaceous clay, above a bed of white silicious or aluminous clay; or by a bed of carbonaceous shale, with thin seams of coal interstratified.

The highest hills west of Big Sandy (near the base line) exhibit the following section:

No. 23. *Section between Jenney's creek and Big Sandy.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy sandstone, coarse grained near the base.				
Conglomerate, filled with white quartz pebbles	626	......	100	......
Covered space above sandstone	526	......	15	......
Coarse sandstone	511	......	64	......
Aluminous shale, place of ore bed at the head of Red river, on "State road," (no ore seen east of Jenney's creek)	447	......	15	......
Coarse sandstone	432	......	32	......
Covered space	400	......	10	......
Fine grained sandstone, in thick beds	389	......	37	......
Covered space, with sandstone at the bottom	352	......	49	......
Sandstone and sandy shale	303	......	94	......
Alternate beds of sandstone and dark sandy shale	209	......	209	......
Bed of Jenney's creek.				
Shales and sandstone	15	......	15	......
Coal, equivalent of the Adamsville and Jackson Rice coal bed	18	......	3	......

On Little Paint creek, two miles further east, an opportunity was offered to fill a portion of the space near the base of Section 23 with a more detailed statement of the materials of that portion of the section, a mass of rock having fallen, leaving a clean cut, of which the following is a section:

No. 24. *Section near Big Sandy, on the east side of Little Paint creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space divided into terraces, the top of the hill being covered by the lower part of the sandstone at 511 feet, Section 23.				
Thin bedded sandstone	4	......	90	2
Sandy shale	8	......	86	2
Sandstone	6	3	78	2
Sandy shale	4	6	71	15
Sandstone	2	1	67	5
Sandy shale	3	2	65	4
Lumpy sandstone	2	6	62	2
Bituminous *coal*	2	......	59	8
Under clay	2	4	57	8
Sandy shale	5	......	55	4
Sandy shale and lumpy sandstone	22	......	50	4
Sandy shale running into sandstone	5	......	28	4
Bituminous shale	2	......	23	4
Bituminous *coal*	2	6	21	4
Under clay	2	......	18	10
Dark gray sandy shale	16	10	16	10
Bed of Little Paint creek.				

The coal at 21 feet 4 inches above, is the equivalent of the coal at the base of Section No. 23.

On Big Sandy river, half a mile above the mouth of Little Paint creek, a bed of bituminous shale is seen, interstratified in the sandy shale, ten feet below the coal. At this point shales, similar in character to those at the base of the section above, extend downward to the bed of the river, 28 feet below the coal.

In the shales, beneath the coal above alluded to, are remarkable sandy segregations, which are generally symmetrical, and circular. One of the largest observed measured 6 feet in its greatest diameter, and four feet thick. The mass was separated into several beds by lines of stratification; at which lines the masses separate, forming circular blocks about six inches thick, the upper and lower portions forming sections of an ellipse. The blocks from the middle of the mass resemble huge unfinished grindstones.

These segregations are valuable as a mark indicating the geological horizon of the Jackson Rice, Adamsville, and Warfield bed of coal; especially as no similar masses have been found in any other horizon than that immediately below this coal bed.

The first of these segregations on our line are found on Stillwater creek, but they are seen on the line in all the valleys which are sufficiently deep, from that point to Tug river. Great numbers of these masses are seen wasted from the shales under the coal at Warfield, lying along the margin of the river, and many partially exposed in the shale beds forming the river bank immediately under the coal bed.

At the mouth of John's creek, on the east side of Big Sandy river, the coal bed at the base of section 24, lies a few feet above the bed of Sandy river.

From this point toward the north we have the following section:

No. 25. *Section from the mouth of John's creek to the coal opened by Mr. Samuel Auxier.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Covered space, sandstone (?)	50	------	285	2
Sandy shale, 10 to 14	10	------	235	2
Sandstone	14	------	225	2
Bituminous *coal*, (Auxier coal)	2	4	211	2
Parting clay	------	4	208	10
Bituminous shale	1	4	208	6
Bituminous shale, earthy	------	6	207	2
Bituminous *coal*, (Auxier coal)	2	------	206	8
Shale and under clay	1	------	204	8
Sandy shale	18	------	203	8
Bituminous coal	------	8	185	8
Under clay (?)				
Sandstone	80	------	185	------
Place of coal on Daniel's creek.				
Sandstone and sandy shale	36	------	105	------
Place of coal on Long branch.				
Sandstone and covered space	69	------	69	------
Top of coal on John's creek.				

It is not improbable that the true thickness of the measures, between the Sam'l Auxier coal and the coal at the mouth of John's creek, is not given in the above section. At the opening made by Mr. Auxier, the dip is found to be towards the northwest, the direction in which the section was measured. If the dip lies regularly in that direction, between the two points measured, the thickness of the measures will be too small in the above section by a quantity equal to the amount of the dip between the two points.

The remarkable bends of John's creek from its mouth to where the line crosses it, about four miles from Sandy river, would indicate considerable disturbance in the measures, even if no rocks were visible. The outcrop in a few places exposes the rocks, which exhibit considerable disturbance and wrinkling; probably the effect of thrust.

Two miles above the mouth of the creek a bed of coal has been opened, in a point of a ridge projecting into one of the bends of the creek. Where opened the bed in four feet thick; which is probably above its average thickness, as the opening is immediately at the axis of a synclinal fold. A short distance down the creek from the opening the unwrought outcrop is seen on anticlinal fold, where the coal is not

more than two feet thick. This bed is probably the equivalent of the upper bed exposed at Little Paint creek, given in Section 24.

A careful examination of the country in the vicinity of the line on John's creek and Daniel's creek, did not result in the discovery of any workable beds of coal between the horizon of the Auxier coal and that opened on John's creek by Mr. Delong, (equivalent to the upper bed at Little Paint.) Two or three thin beds of coal were found in the space between these beds, but none of them attained a greater thickness than from fifteen to thirty inches, if, indeed, the latter figures are not too high.

The coal beds opened by Mr. Delong, at the base of the section, as well as the equivalent of that opened by Mr. Auxier, are accessible the entire distance between Big Sandy and Tug river, in the immediate vicinity of the line.

On Tug river, at Warfield, the lowest bed in Section 24 is opened about forty feet above the bed of the river. It is about four feet thick, where it was seen near the town, on the southwest side of Warfield, where it occupies a position a little lower than at the works on the river. This indicates a slight dip to the northwest, and with the line of the river at this place.

The base line from the valley of John's creek crosses obliquely the ridges dividing the streams flowing into Tug river, and those flowing into John's creek and Big Sandy. The line crosses this ridge on the 288th mile, six miles east of the mouth of John's creek.

The line from the 288th to the 292d mile lies across the head branches of Rockcastle creek. The Beech fork is the first branch crossed; then Stonecoal fork, Scaffold fork, main Rockcastle, Lick fork, Laurel fork, and many small nameless branches. On the 292d mile, the line enters the "*breaks*," and crosses the ridge dividing Rockcastle and the Panther fork of Wolf creek. The 295th mile enters the White Cabin fork of Wolf creek. The 297th mile crosses main Wolf creek. On the 298th mile, Peter Cave creek, a large branch of Wolf, is crossed. Pigeon Roost fork is crossed on the 299th mile, the mile post falling on the summit of the ridge, on the east side of it, and the dividing ridge between White Oak fork of Emily's creek and Pigeon Roost. The 301st mile crosses White Oak. The 303d mile post is erected on the terraces on the east side of Emily's creek. The 305th mile reaches and crosses the head of several small branches of Big

creek. These branches run south from the line, which now enters the breaks of Tug river, at the head of Mt. Sterling branch.

It will be seen, by the foregoing summary, that the creeks crossed by the line are very numerous. The small nameless drains are nearly as deep as the valleys of the main creeks.

The spurs from the main ridges between the drains are generally as high as the dividing ridges themselves. In almost every instance the hills between the creeks, branches, and drains are capped by the heavy sandstone associated with the upper conglomerate bed, the valleys being from 300 to 500 feet deep, the drainage cutting into the measures nearly down to the Jackson Rice, Little Paint creek coal, frequently below it.

Practically the line lies on the strike line of the measures, which is modified locally by waves, wrinkles, and a few inconsiderable faults or breaks, the latter being readily recognized by the low gaps breaking the main ridges.

On the Stonecoal fork of Rockcastle creek, a bed of coal is exposed in outcrop, 244 feet below the "Bear Wallow Gap." On the ridge southeast of the gap, the great sandstone, which caps the hills, rises about 100 feet above the gap.

This coal is probably the equivalent of the Samuel Auxier bed of coal heretofore alluded to, and has been so considered.

The following section begins at the top of the ridge, and extends down Stonecoal fork about a mile, crossing to the north side of the base line, nearly at the middle of the distance.

No. 26. *Section on Stonecoal fork of Rockcastle creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Heavy masses of sandstone	100	------	431	1
Covered space, shale, sandstone, &c.	244	------	331	1
Bituminous *coal*	7	------	87	1
Parting, clay	------	5	80	1
Bright, hard bony *coal*	3	------	79	8
Dark silicious shale	10	------	76	8
Coarse sandstone	35	------	66	8
Dark sandy shale 15 to 20 feet	15	------	31	8
Bituminous *coal*	1	3	16	8
Under clay	2	------	15	5
Bituminous fossiliferous limestone	1	5	13	5
Sandy shale	12	------	12	------
Rockcastle creek, (sandstone.)				

The bituminous limestone is a most remarkable bed; it lies in blocks nearly square, from 15 to 18 inches thick.

The dividing ridge between main Rockcastle creek, and the head of Lick fork, is capped by a portion of the sandstone associated with the conglomerate beds which are seen in considerable force at the "Piney Gap." All the drains and branches are strewn with white quartz pebbles wasted from this top hill sandstone.

The following section, obtained at the divide separating Laurel fork of Rockcastle creek from the Panther fork of Wolf creek, will serve to give more in detail the measures in the covered space of 244 feet in Section 26 :

No. 27. *Section of the ridge between Laurel fork of Rockcastle and Panther fork of Wolf creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches.
Sandstone, with large blocks of conglomerate near the base of the mass	50	------	297	8
Sandy slope, (sandstone?)	30	------	247	8
Sandstone, bed soft at top	38	------	217	8
Covered space, sloping, (shales?)	25	------	179	8
Sandstone	35	------	154	8
Covered space, showing shales, (coal at top?)	25	------	119	8
Hard sandstone (*Rock houses*)	18	------	94	8
Sandy shale	20	------	76	8
Bituminous coal, 18 to 20 inches	1	88	56	8
Dark sandy shale	25	------	55	------
Bituminous coal, size not seen ; dark sandy shales	15	------	30	------
Hard sandstone	15	------	15	------
Coal in bed of Laurel fork.				

Descending the valley of Panther fork of Wolf creek, the only line of travel practicable was in the bed of the branch. The rocks dip with the line of the stream nearly as rapidly as the fall of the branch itself. Two thin beds of coal were cut and brought to light by the branch; these should be placed in the upper part of the section. One bed is about 15 inches thick, and probably occupies a place in the section above at 179 feet 8 inches; the other, about 2 feet thick, at 119.8.

From Rockcastle creek eastwardly to Tug river the upper sandstone, which caps the hills so frequently referred to, caps the points and ridges as naked masses, which, seen from a distance, might readily be taken for castles or artificial structures.

The valley of Wolf creek, which is quite a large stream, is generally only a few feet wide. In many places the abrupt ascent of the hills begins at the wa'er's edge on both sides of the stream; at all such places the only road lies in the bed of the creek.

The lower part of the hills are wooded with beech, poplar, ash, sugar-tree, gum, sour wood, and oak; the sides higher up with different species of oak; the *gaps, caves*, and top of the ridges are clothed with chestnut-oak, and pine.

A bed of coal, 7 feet thick, has been seen one mile south of the line, at the head of White Cabin branch of Wolf creek. I was not able to visit the locality of this coal. It is probably the upper part of the great bed seen on Stonecoal fork of Rockcastle, four miles further to the west.

At Mr. Samuel Moore's mill, three quarters of a mile south of the line, a bed of coal outcrops in the bed of the creek; it is about 20 inches thick. This bed must lie below the 7 feet coal above referred to. These beds are referred to as being equivalent to the upper part of the great coal of Rockcastle creek, and the first coal below it given in Section 26. If this reference be correct, then there are four horizons of coal in the first 350 feet below the conglomerate, which here caps the hills.

On our return from Tug river, a thin cannel coal was observed in several hills; it is the first coal under the conglomerate.

No satisfactory exhibition of the cannel coal bed was obtained. It is probably not over 18 inches thick, where it was crossed by the road from Warfield to the mouth of John's creek.

The base line crossed the Pigeon Roost fork of Wolf creek, half a mile north of James Howard's mill; near the mill there is a perfect exhibition of the following section:

No 28. *Section of coal, &c., at Howard's mill, Pigeon Roost fork of Wolf creek.*

	Thickness.		Elevation.	
	Feet.	Inches.	Feet.	Inches
Heavy sandstone, south of gap	80	------	429	6
Covered space	45	------	349	6
Covered space, divided into three terraces	241	------	304	6
Sandstone, thick beds	25	------	63	6
Sandy shale	15	------	38	6
Bituminous *coal*	2	------	23	6
Sandy shale	15	------	21	6
Bony bituminous *coal*	4	------	6	6
Under clay	2	6	2	6
Dark sandy shale, bed of Pigeon Roost fork of Wolf creek.				

White Oak fork of Emily's creek exhibits the upper part of section imperfectly. Although White Oak creek was traced to its junction with Emily's fork, and the latter stream carefully examined for four miles above the mouth of White Oak, no section could be obtained which would add any information to that already given.

The shale beds have probably increased in thickness east of Rock-castle creek. The rocky masses are softer east of Wolf creek than the equivalent beds are at the west. The hills are covered by the debris of rocks and shales, notwithstanding their sides form angles with the horizon ranging from 25° to 60°.

No further sections of the measures outcropping on the line were obtained. The tops of the hills are always capped by the heavy sand-stone and its associated conglomerate beds, giving assurance that no new measures were to be examined, and that additional sections would be the equivalent of those already given, variously modified.

The unsettled and variable state of the weather since the passage of Jenney's creek has rendered the barometrical observations quite unreliable. No confidence has been given to observations taken at intervals longer than from fifteen to twenty minutes apart.

The observations by barometer between Jenney's creek and Tug river consist of a series of one hundred and seventy-six observations, besides twenty-four observations between Tug river and John's creek, on our return.

By the observations made on the road between Warfield and John's creek, the place of the cannel coal is set down at 97 feet below the gap at the head of Buck creek, or about 120 feet below the conglomerate, on the hill tops, and 94 feet below the ridge east of Mr. Cassiday's, on Rockcastle creek.

From John's creek, our route, returning, was down Big Sandy to the mouth of Big Paint creek, up this to the divide separating Little Paint fork of Big Paint from the latter; across this ridge to Little Paint fork, which was traced to its head, crossing the ridge, and descending the Road fork of the Burning fork of Licking river to Adamsville.

The road lies near the top of the Licking shales, sometimes sinking a little below the Adamsville coal, sometimes rising 75 to 80 feet above it.

To the northwest of Paintville, considerable disturbance was observed in the rocks under the Adamsville coal. The measures being thrown into waves, the axis of which is northeast and southwest, subsequently these troughs have been filled by deposits lying non-conformable.

It will be seen by what has been stated in this chapter that the coal beds increase in thickness and number east of Big Sandy; and, as far as can be seen in unwrought outcrop, the coal appears to be of excellent quality. On the west side of Big Sandy near our line, the coal beds are thinner and frequently separated by clay partings. The beds of iron ore cease and are not seen east of the head of the Green Rock fork of Jenney's creek. The horizon of the ore beds was frequently exposed eastwardly of this point, but no ore beds were seen.

By reference to Vol. 3, Kentucky Geological Reports, sec. 3, pages 330, 331, it will be seen that a ferruginous conglomerate occurs at 311 feet. The same geological horizon is in the succeeding sections, viz: Section 4, at 220 feet; section 5, at 396 feet; section 8, at 256 feet; section 9, at 360 feet; and in section 10, at 244 feet 10 inches. These sections are all taken near the margin of the coal field in Greenup and Carter counties; in all the conglomerate is found. In the last section the whole thickness of the coal measures lying between this remarkable bed of conglomerate and the sandy beds beneath the sub-carboniferous limestone, and including what remains of that division, is only 244 feet 10 inches.

The dividing ridge between Little Sandy and Tygert's creek carries the conglomerate bed to the vicinity of Laurel furnace. It is seen

again on the east side of Little Sandy, at Steam furnace, above the Carrington and Heighton ore banks. It occurs at the head of Indian creek, and follows the line of the ridge to the ore diggings of Caroline furnace, further to the southeast. It is seen again at Clinton furnace; the same bed at Mt. Savage furnace, (sec. 9,) twenty miles to the south, persistently capping the highest hills in the coal measures in Greenup and Carter counties. The column of the coal measures steadily increasing in height to the southeast, is always capped with this pebbly bed, except in the neighborhood of Amanda furnace, where a thin patch of the coal measures rise above it. (See page 453, vol. 3, Ky. Reports.)

To the horizon of the conglomerate bed mentioned above is referred the great sandstone mass, which so persistently occupies the head of the section on the base line east of the head of Red river. A line of sections across the country from Mt. Savage furnace to the head of Jenney's creek would place this question at rest, and, at the same time, determine the margin of the iron ores toward the southeast from Mt. Savage furnace, thus connecting the observations of the base line with the work of Greenup, Carter, &c., on the north.

The thickening of the coal measures toward the south and southeast has been satisfactorily established. At Jenney's creek we have above the Adamsville coal over 600 feet of shale, sandstone, and coal; below the Adamsville coal the Licking shales are from 150 to 200 feet thick, to which should be added the great sandstone at the base of the coal measures lying above the coal and iron ore beds of Estill county; this latter mass is about 240 feet, making together over 1,000 feet of measures on Sandy river, (supposing the lower measures, which are concealed, retain the thickness they have at the west,) against 244 feet 10 inches, as per sections on Smith's and Coal creeks, near the margin of the coal measures west of Little Sandy river in Greenup county.

After entering the coal measures, the general dip is to the south, frequently reversed by waves and a few minor faults. The small streams are generally in the line of the synclinal and the ridges the anticlinal waves.

The main anticlinals are remarkably serpentine, and throw off secondary anticlinals, into spurs to the right and left, direct and obliquely toward the east and west.

The hills rise toward the head of the streams or main dividing ridges,

as much, frequently more, by the dip lying with the downward course of the streams, than by the addition of measures toward the great dividing ridges; both causes are generally combined; especially when the remains of the great upper conglomerate sandstone are still in place.

The hills at the head of Red river, Burning fork of Licking, Rockcastle, and Wolf creek, are nearly on the same horizon.

The accompanying diagram of the base line will probably explain the character and elevation of the measures and the country better than anything I could add to what has already bcen said.

INDEX.

ERRATA, &c.

Page 241, 6th line from top, "NELSON COUNTY" should be NICHOLAS COUNTY.

Page 248, under 2d line, add *Composition of the Ash.*

Page 324, for "*Catherine* Neef" read *Caroline* Neef.

Page 338, (foot note,) for *my* Report read *First* Report.

Page 355, line 19, for *cari*folius read *cavi*folius.

Page 357, line 17, for *Fine* clay read *Fire* clay.

Page 370, line 5, for *oveo*pteridius read *oreo*pteridius.

Page 374, line 12, for Schi*z*opteris read Schi*s*opteris.

N. B. In the section on page 387, as well as in the others in M. Lesquereux's Report, the distance between the strata is not printed exactly according to the scale laid down, viz: 1 inch to 200 feet, although the numerals are accurately printed.

Page 399, in the Section, 3d coal right hand, the place of Coal A 8th should be 20 feet below that of C. 9th.

Page 414, line 2, for page 40 read 357.

Page 428. These printed tables of comparative sections are not accurate according to the scale laid down, although the numerals are correct; they have, consequently, been accurately repeated in the lithographic plate inserted here.

Page 431, at the base of the Warfield section, read, at 125 feet, *first brine*, and at 525 feet, *strong brine*.

Page 433, line 3d, for Alet*hr*opteris read Alet*ho*pteris. At the bottom of the page, add: *Is very abundant with coal No. 4th.*

Page 448, 9th line from the bottom, for *t*own branch read *T*own branch.

Page 448, 13th line from the bottom, for Min*ce's* read Min*er's*.

NOTE.

The Geological Survey of Kentucky—which sustained such a heavy loss, in November last, in the death of our distinguished Chief Geologist, David Dale Owen, M. D.—was brought to a pause by the failure of the Legislature, at its next following session, to make the necessary appropriation for its continuance. This, with the present distracted state of the country, may postpone its completion for an indefinite period.

The present volume embodies most of the materials, ready for publication, which had been reported to Dr. Owen before his death—and its general arrangement for the press was made by him; but it is proper to state that a large and valuable mass of matter still remains, in field notes and in other forms, in the hands of the various members of the late Geological Corps, which, should the Survey not be resumed at some not distant day, may be lost to the State and to Geological Science.

ERRATA TO S. S. LYON'S REPORT.

Page 503, line 18 from top, read "on the top of the whole body," &c., for "on the top of which rests the whole body."

Page 504, line 22 from top, for *Fur* fork read *Tar* fork.

Page 506, line 23 from top, for Phyriformis read pyriformis.

Page 507, line 3 from top, for *Doverty's* creek read *Dorerty's* creek.

Page 508, 3d and 9th lines from bottom of page, for *Chandoin* read *Chaudoin*.

Page 509, 23d line from bottom, for *Chandoin* read *Chaudoin*.

Page 511, 17th line from bottom, for *places* read *faces*.

Page 515, 15th line from bottom, for 21 read 210.

Page 516, 23d line from bottom, for 21 read 218.

Page 516, 22d line from bottom, for 20 read 200.

Page 516, 21st line from bottom, for 141 read 151.

Page 519, 13th line from bottom, for *hackleberry* read *hackberry*.

Page 528, 8th line from bottom, for Penbratulæ read Terebratula.

Page 558, 3d line from top, for Lichfield read Litchfield.

Page 558, add 7 feet to each sum above 3d line from base of Section No. 28.

Page 562, 8th line from base of Section 30, for Hodger's read Hodge's.

Page 564, 4th line from base of Section 31, for Plerotocrinus read Pterotocrinus.

Page 567, 8th line from base of Section 34, for 6 feet read 6 inches.

Page 567, 9th line from base of Section 34, for 2 feet read 2 inches.

Page 567, 10th line from base of Section 34, for 4 feet read 4 inches.

Page 567, 11th line from base of Section 34, for 2 feet read 6 inches.

And extend the sum 40 feet 6 inches, instead of 39 feet 8 inches.

Page 567, 6th line from bottom, for Orthoceratiti read Orthoceratite.

Page 567, bottom line, for Balen read Baleu.

Page 572, 8th line from bottom of Section 39, for 92 feet read 91 feet.

Page 572, 9th line from bottom of Section 39, for 125 feet read 124 feet.

Page 572, 10th line from bottom of Section 39, for 140 feet read 139 feet.

Page 573, 4th line from top, for "is seen" read "as seen."

Page 580, 8th line from top, for "when intersected" read "where intersected."

Page 580, 9th line, for line A read line N.

Page 581, 8th line from bottom, for "the clear coal of the Hunting branch of Clear creek" read "the twin coal," &c.

Page 585, 5th line from top, for *Rudy's* read *Reedy's*.

Page 589, 1st line top of Section 23*, for "Thickness" read "Elevation," and for "Elevation" read "Thickness."

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* This should be 43.